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# The interplay between instructional policy and its constituents: How mathematics teachers interact with and understand "Principles and Standards for School Mathematics"

Dawn M. Berk

*University of New Hampshire, Durham*

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THE INTERPLAY BETWEEN INSTRUCTIONAL POLICY AND ITS  
CONSTITUENTS: HOW MATHEMATICS TEACHERS INTERACT WITH AND  
UNDERSTAND *PRINCIPLES AND STANDARDS FOR SCHOOL MATHEMATICS*

BY

DAWN M. BERK

BA, St. Mary's College of Maryland, 1993

MS, University of New Hampshire, 1997

DISSERTATION

Submitted to the University of New Hampshire  
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In

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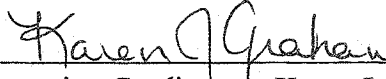
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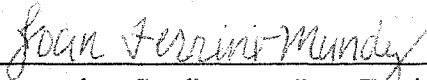
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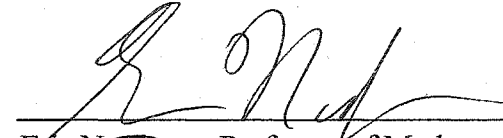
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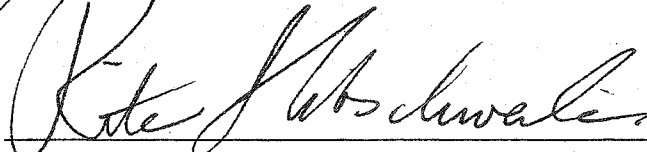
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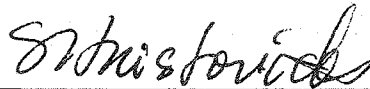
Dissertation Co-director, Joan Ferrini-Mundy, Professor of  
Mathematics and Teacher Education, Michigan State University



Eric Nordgren, Professor of Mathematics



Rita Hibscheweiler, Professor of Mathematics



Sonia Hristovitch, Assistant Professor of Mathematics

August 30, 2004  
Date

## **DEDICATION**

**For my parents, Patricia and Richard Berk**

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## ABSTRACT

### THE INTERPLAY BETWEEN INSTRUCTIONAL POLICY AND ITS CONSTITUENTS: HOW MATHEMATICS TEACHERS INTERACT WITH AND UNDERSTAND *PRINCIPLES AND STANDARDS FOR SCHOOL MATHEMATICS*

by

Dawn M. Berk

University of New Hampshire, December, 2004

Educational policies aimed at reforming school mathematics education have been disseminated at an increasing rate in recent years. The impact of such policies hinges on if and how constituents decide to implement the policy recommendations, and these decisions depend largely on constituents' interpretations of the policy. Investigating how classroom teachers make sense of policy recommendations is particularly important, for teachers are the ones who ultimately decide what mathematics students learn, and how they learn it. This research followed a group of teachers as they studied a particular instructional policy, *Principles and Standards for School Mathematics* (NCTM, 2000). Fourteen middle school mathematics teachers formed a study group to read and discuss the document's messages and recommendations. This study aimed to characterize the nature and content of teachers' discussions, to trace the ideas teachers developed about the document, and to investigate the impact this experience had on teachers' beliefs, knowledge, priorities, and classroom practice.

Data sources included audio and videotapes of sixteen study group sessions, teacher journal entries, electronic listserv discussions, interviews, and classroom

observations. Analyses of the study group discussions were conducted in two phases. The first phase consisted of a turn-by-turn analysis of each teacher's individual contributions to the conversations. The second phase consisted of a more global analysis in which each study group transcript was chunked into distinct conversational episodes. Coding schemes were developed to capture the major themes that emerged in the study group conversations, and to characterize the cognitive demand posed by the topic under discussion and by the group's treatment of that topic.

Results indicate that teachers came to view the document from multiple lenses – as a warrant for their current beliefs or practices, a lever for effecting change, a tool for their own learning, and a curriculum map. The ways in which teachers came to view the document were related to the particular demands, priorities, and characteristics of their local school contexts. Results suggest that instructional policy documents like *Principles and Standards* can be generative – they can stimulate rich conversations among teachers, and such conversations are fruitful sites for teachers' professional learning.

## CHAPTER 1

### INTRODUCTION

The reform ideas that implementers construct from a policy influence what they do, and do not do, in implementing that policy.... Implementation involves interpretation because implementers must figure out what a policy means to decide whether and how to ignore, adapt, or adopt policy locally. (Spillane & Callahan, 2000, p. 404-405)

The past twenty years have witnessed an unprecedented rise in the creation and dissemination of educational policies aimed at reforming K-12 education in the United States. Initiated in the early 1980's by policy documents like *A Nation at Risk* (National Commission on Excellence in Education, 1983) and *Educating Americans for the 21<sup>st</sup> Century* (National Science Board, 1983), this policy proliferation is exemplified by the development of a series of "standards" for school mathematics education by the National Council of Teachers of Mathematics.<sup>1</sup> Central goals embodied in these standards include shifting the focus of the school mathematics curriculum from an emphasis on learning mathematical facts and procedures to developing conceptual understanding and the ability to use mathematics to solve problems, and shifting the dominant paradigm of mathematics instruction from teacher-as-teller and student-as-receptacle of knowledge to teacher-as-facilitator and student-as-constructor of mathematical knowledge.

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<sup>1</sup> *Curriculum and Evaluation Standards for School Mathematics*, 1989; *Professional Standards for Teaching Mathematics*, 1991; *Assessment Standards for School Mathematics*, 1995; *Principles and Standards for School Mathematics*, 2000. The set consisting of the 1989, 1991, and 1995 documents will hereafter be referred to as the *Standards*.

In this milieu of educational reform, policy documents like the NCTM *Standards* are used to communicate the central reasons for and goals of reform and to serve as a lever for change at various levels of the educational system. As the opening quote from Spillane and Callahan (2000) suggests, the success of such policies hinges on if and how various constituents decide to implement (or not implement) the policy recommendations, and these decisions depend largely on the interpretations and understandings constituents develop about the policy. In particular, understanding how *classroom teachers* take up and make sense of instructional policy recommendations is crucial to anticipating and understanding a policy's success, for (as many have noted) teachers are often the primary instruments of instructional reform (Borko & Putnam, 1995; Cohen, 1990; Cohen & Ball, 1990a, 1990b; Spillane & Callahan, 2000).

Regardless of the various forces that aim to influence classroom instruction – state and district policies, vehicles for teacher and school accountability, community expectations and values, to name a few – teachers are the ones who ultimately decide what mathematics students learn, and how they learn it. In fact, the situation is even more complex: teachers are not only the chief means of implementing reform, but also the primary target of reform (Borko & Putnam, 1995; Cohen & Ball, 1990a, 1990b). Cohen and Ball (1990a) describe this dilemma: “Teachers are, in one sense, the problem that policy seeks to correct. On the other hand, teachers are the most important agents for improving things: Students’ encounters with mathematics in school will not change unless teachers change them” (p. 238). Thus, teachers are needed to implement change, and yet to do so, they need to change themselves – their beliefs, knowledge, goals, values, and classroom practice.

Given this paradoxical situation – that teachers are “simultaneously the objects and the agents of change” (Borko & Putnam, 1995, p. 60) – it becomes clear that supporting teachers in developing an understanding of policy recommendations, considering the implications of the recommendations for their practice, and ultimately revising their practice in light of those recommendations is necessary if educational policy documents like the *Standards* are to have any chance of success. Unfortunately, in the fervor over developing and disseminating educational policies, attempts to provide intended audiences with opportunities to make sense of policy recommendations have been few and far between.<sup>2</sup> Moreover, efforts to understand how teachers gain access to policy documents like the NCTM’s *Standards*, and how they make sense of them, have been rare. This study sought to address this gap in our understanding by investigating a group of middle school mathematics teachers as they worked to study and make sense of the NCTM’s latest standards document, *Principles and Standards for School Mathematics* (2000).<sup>3</sup>

### **Rationale for the Study**

There are several reasons for investigating mathematics teachers’ interpretations of a policy document like *Principles and Standards*. First, there have been few efforts to provide teachers with opportunities to seriously engage with policy documents like the

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<sup>2</sup> Initiatives such as the NCTM Academies for Professional Development, the Outreach Kit, and the Administrator Task Force represent very recent efforts by NCTM to support teachers and other constituents in interpreting and implementing *Principles and Standards for School Mathematics* (2000).

<sup>3</sup> This most recently published document will hereafter be referred to as *Principles and Standards*.

NCTM *Standards*.<sup>4</sup> A review of the literature suggests that teachers typically learn about the *Standards* by attending some sort of professional development experience run by an expert or experts, by reading about the documents in journals or newsletters, or by hearing other teachers or administrators talk about them. Indeed, although many recent professional development efforts aim to increase teachers' awareness of the *Standards* or to promote "standards-based" mathematics instruction, few actually engage participants in first-hand experiences with the documents (Borasi & Fonzi, 1997; Stein & Lane, 1996). Rather, teachers' experiences with the *Standards*, and their resulting understanding of the recommendations and implications of those documents, are typically filtered through the leaders and the curriculum of the professional development experiences. Yet it remains unclear whether these "experts" are truly familiar with the documents. In fact, "No one has really read the *Standards*" is a comment that is frequently tossed about in conversations among mathematics educators. While meant to be facetious, this comment suggests a perception that while many mathematics educators might claim to be aware of the *Standards*, and perhaps even be working to implement them, few have actually studied the documents carefully.

Indeed, programs in which teachers interact directly with policy documents aimed at influencing classroom practice – through reading, discussing, and analyzing the documents with other teachers – are rare. Most often, teachers' exposure to the documents' messages and ideas have been filtered through the perspectives and interpretations of others. How might we create more "authentic" opportunities for teachers to engage directly and intensely with policy documents like the *Standards*? What

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<sup>4</sup> If such efforts exist, they have not been well documented.

form might such opportunities take? How could such experiences be designed and facilitated in ways that would be meaningful to teachers? This study aims to describe such an experience for teachers and to investigate the understandings they developed as they studied *Principles and Standards*.

A second reason for investigating teachers' interpretations of the *Standards* is to address a recognized gap in the research. Despite a paucity of more "authentic" experiences, teachers do manage to glean ideas about policy documents like the *Standards* from secondary sources and often draw on these ideas to make decisions about their practice. Unfortunately, we know very little about how teachers come to make sense of such documents. Indeed, very little empirical work has been done to characterize the ways in which teachers come to interpret the messages and recommendations of policy documents. A few notable exceptions do exist, such as the California Study of Elementary Mathematics (Cohen & Ball, 1990a; Peterson, 1990), the Recognizing and Recording Reform in Mathematics Education (R<sup>3</sup>M) project (Ferrini-Mundy & Schram, 1996), and the work of Weiss and her colleagues (2001). Although studies like these attempt to characterize teachers' perceptions and understandings of the NCTM *Standards*, they typically enter the policy "impact scene" at the point at which teachers have already drawn conclusions about the messages of the *Standards* and enacted corresponding decisions in their classrooms. By entering the scene at this stage, these studies are often unable to shed much light on how and why teachers have come to develop their particular understandings of the documents. In contrast, this research aimed to contribute to the literature by investigating and characterizing the ideas teachers

develop about *Principles and Standards*, in “real time”, as they study the document and strive to make sense of it.

A final comment about the current knowledge base regarding how teachers interpret documents like the *Standards* is in order. Empirical evidence from a handful of studies, along with anecdotal stories, seem to have contributed to a shared view in the mathematics education community that, for the most part, teachers have either shallowly interpreted or completely misinterpreted the *Standards* (Cohen, 1990). This portrayal of teachers (or of constituents of policy more generally) is suspect for two reasons. First, there simply is not enough empirical evidence to warrant this characterization. Second, the line of reasoning underlying this characterization of teachers seems faulty. These studies often take the changes teachers have (or have not) made to their classroom practice in response to the *Standards* as a proxy for their interpretations of the *Standards*. This can be problematic, for there is no reason to expect that teachers’ practice would be identical to their interpretation of the policy.<sup>5</sup> Indeed, a complex host of factors contribute to the decisions teachers make about what mathematics to teach and how to teach it, and these factors often communicate conflicting messages to teachers. Moreover, implementing the recommendations in policy documents like the *Standards* requires significant shifts in teachers’ beliefs about mathematics and mathematics teaching and learning, and such shifts take a long time to occur (Anderson & Helms, 2001; Little, 1993). Thus, it is quite possible that a teacher could interpret a policy document like the *Standards* as the authors intended, but struggle to put those interpretations into practice in

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<sup>5</sup> For example, results from a pilot study (Berk, 1998) revealed that teachers often work under constraints (i.e., limited time and/or resources, demands from parents and administrators, lack of support for innovation) that force them to make compromises to their practice.



the classroom. In other words, teachers' efforts to implement the *Standards* are not necessarily an accurate and complete reflection of the understandings they have developed about the documents' recommendations. By focusing on the ideas teachers develop as they read and study *Principles and Standards* in "real time", this study aims to measure teachers' interpretations directly.

Finally, a third reason for investigating the ideas teachers develop about *Principles and Standards* as they read and study the document with other teachers is the potential for such an investigation to contribute to the literature on teacher education and professional development more generally. Designing and then investigating ways to engage teachers in understanding and taking on the recommendations of instructional policy documents are imperative in order for reforms to be implemented. However, one can move past the concerns of educational reform, adopting a different perspective and posing a more general question: Beyond learning about and beginning to move toward proposed reforms, what other opportunities to learn, if any, do instructional policy documents like the *Standards* potentially provide for teachers? In other words, what might teachers learn – about mathematics and mathematics teaching and learning, or about themselves as professionals and learners – by engaging in the work of making sense of a policy document? What impact might such work have on teachers' beliefs, priorities, and classroom practice? Would such work be worthwhile to teachers, beyond gaining a better understanding of the policy? If so, what features of the policy document, or of the experience by which teachers study the document, might prove most effective in supporting teacher learning and change? Such questions about the potential of

instructional policy documents for teacher change and teacher learning have only begun to be taken up in a significant way by the mathematics education research community.

In summary, the motivation for this study is three-fold. First, this study aims to provide teachers with a unique professional development experience in which they engage directly and extensively with a nationally recognized instructional policy document, namely the NCTM's *Principles and Standards*. Second, this study aims to contribute to our understanding of the types of ideas teachers develop about the document within this environment. Only by understanding how various constituents make sense of and use educational policy can we better understand the impact policy may have. Such work can also inform future development of educational policies aimed at improving instruction. Third, this study will explore the potential of a policy document like *Principles and Standards* to serve as a tool for teacher learning, beyond the realm of the specific policy. Of course, in order to investigate what opportunities to learn the document might afford teachers, we must first understand what the document has to offer. Thus, the next section presents a brief description of *Principles and Standards* – its purpose, structure, and main messages.

### **Overview of *Principles and Standards***

*Principles and Standards for School Mathematics*, released by the National Council of Teachers of Mathematics in April 2000, proposes the following idealized vision for school mathematics education:

Imagine a classroom, a school, or a school district where all students have access to high-quality, engaging mathematics instruction. There are ambitious expectations for all, with accommodation for those who need it. Knowledgeable teachers have adequate resources to support their work

and are continually growing as professionals. The curriculum is mathematically rich, offering students opportunities to learn important mathematical concepts and procedures with understanding. Technology is an essential component of the environment. Students confidently engage in complex mathematical tasks chosen carefully by teachers. They draw on knowledge from a wide variety of mathematical topics, sometimes approaching the same problem from different mathematical perspectives or representing the mathematics in different ways until they find methods that enable them to make progress. Teachers help students make, refine, and explore conjectures on the basis of evidence and use a variety of reasoning and proof techniques to confirm or disprove those conjectures. Students are flexible and resourceful problem solvers. Alone or in groups and with access to technology, they work productively and reflectively, with the skilled guidance of their teachers. Orally and in writing, students communicate their ideas and results effectively. They value mathematics and engage actively in learning it. (NCTM, 2000, p. 3)

The document then offers a comprehensive set of goals, packaged in the form of six guiding Principles and ten Standards, aimed at guiding school mathematics curriculum, teaching, and assessment in ways that will support all parties involved in working toward this vision. It is important to note that *Principles and Standards* is an extension and consolidation of the original *Standards* documents, not a replacement or alternative. It begins with the recommendations and messages presented in these earlier documents, and then builds on these ideas by incorporating and interweaving what the field has learned about mathematics teaching and learning over the past ten years.

*Principles and Standards* is organized into eight chapters. Chapter 1 provides an introduction and makes a case for the need for and the role of standards documents in improving school mathematics education. Chapter 2 presents and elaborates a set of six Principles aimed at highlighting important issues that can guide the development and improvement of school mathematics instructional programs. (See Table 1.)

**Table 1. Six Principles for School Mathematics**

**Equity:** Excellence in mathematics education requires equity – high expectations and strong support for all students.

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**Curriculum:** A curriculum is more than a collection of activities: it must be coherent, focused on important mathematics, and well articulated across the grades.

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**Teaching:** Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well.

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**Learning:** Students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge.

---

**Assessment:** Assessment should support the learning of important mathematics and furnish useful information to both teachers and students.

---

**Technology:** Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning.

---

In Chapter 3, an overview of the ten Standards that specify the mathematical content and processes that students should know and understand is presented. The first five standards – the Content Standards – describe in detail the mathematics content that students should learn. The five content standards are Number and Operations, Algebra, Geometry, Measurement, and Data Analysis and Probability. The next five standards – the Process Standards – describe processes through which students learn and employ mathematical content knowledge. The five process standards are Problem Solving, Reasoning and Proof, Communication, Connections, and Representation. Chapter 3 then sketches the developmental trajectory of each Standard as students move from pre-kindergarten through grade twelve. More detailed discussion of each Standard is then taken up within each of four grade bands – pre-kindergarten through grade two, grades three through five, grades six through eight, and grades nine through twelve. Finally, Chapter 8 describes

how the vision of mathematics education put forth in the document might be achieved, and the roles that various constituents need to assume in order to move toward the vision.

**Table 2. Ten Standards for School Mathematics**

Content Standards	Process Standards
Number & Operations	Problem Solving
Algebra	Reasoning and Proof
Geometry	Communication
Measurement	Connections
Data Analysis & Probability	Representation

### **Research Questions**

This research study sought to capitalize on the April 2000 release of *Principles and Standards* as a means of pursuing some of the questions posed in the above discussion. Under my direction, fourteen middle school mathematics teachers in mid-Michigan voluntarily formed a study group to collaboratively read and study *Principles and Standards* over the course of five months.<sup>6</sup> This research provides a window into the experiences and efforts of this particular group of teachers to make sense of a particular instructional policy document. By doing so, this research aimed to investigate the following questions:

When teachers are given an opportunity to form a study group and carefully read, analyze, and discuss an instructional policy document like *Principles and Standards*,

- 1.) What is the nature and content of the teachers' discussions of the document?

---

<sup>6</sup> A subgroup of the teachers continued their study of the document for an additional three months.

- 2.) What ideas do individual teachers develop about the policy – its purposes, messages, and recommendations?
- 3.) What impact, if any, does the experience have on individual teachers' beliefs, knowledge, priorities, and classroom practice?

The first question focuses on characterizing the nature of the teachers' discussions of the document in the context of the study group. What would teachers talk about? In what ways would they participate in the conversations? The second question concentrates on characterizing the teachers' responses to and ideas about *Principles and Standards* that they develop as they read and discuss the document in the study group. Such characterizations would include how teachers saw themselves using the document, and to what purposes, how teachers viewed the document as a whole, and how teachers interpreted particular or "local" passages of the document. I was also curious to see if different teachers interpreted the document in different ways. If so, what might explain such differences? Finally, the third question can be thought of as the "So, what?" question. It focuses on what impact the study group experience might have on participating teachers, outside of enabling them to develop awareness and understanding of *Principles and Standards*.

At this point, some caveats are in order. My primary interests were in how teachers would engage with and make sense of *Principles and Standards* if given an opportunity to do so, how to design such an experience in a way that would be meaningful to teachers, and what teachers could learn from participating in such an experience. The aim of this work was not to convince teachers to "believe" or "implement" the document. In other words, this was not an advocacy effort. Rather, I was

open to and prepared for possible dissent among the teachers and rejection of some or all of the document's stances and recommendations. Second, it is important to note that the research did not aim to change, or to investigate possible changes in, teachers' classroom practice. Making "alignment" of teachers' practice to the document an explicit goal of the professional development would have been putting the proverbial cart before the horse.<sup>7</sup> How can teachers align their practice to *Principles and Standards* until they have developed their own conceptions of the document's vision and underlying philosophy? Finally, the same can be said for student learning. To try to link the professional development to changes in student achievement or learning, while provocative, was beyond the scope of this research, and I would argue, inappropriate at this stage.

In the next chapter, relevant literature in educational policy and professional development is reviewed as a means of building a case and setting the context for the present research. The theoretical framework that guides this study is also described. Chapter 3 describes the context of the study – a professional development project designed as a study group for middle school mathematics teachers in mid-Michigan – and the research methodology. In Chapter 4, the first research question is addressed. Chapters 5, 6, and 7 address the second and third research questions through case studies of three of the participating teachers – Brian, Janelle, and Joyce. Finally, conclusions and implications are discussed in Chapter 8.

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<sup>7</sup> What it means for classroom practice to be "aligned with" the recommendations of the document is, in itself, problematic. Operationalizing and investigating this construct will be an important direction for future research.

## CHAPTER 2

### LITERATURE REVIEW AND THEORETICAL FRAMEWORK

In this chapter, relevant literature in educational policy and professional development will be reviewed as a means of building a case and setting the context for the present research. The chapter begins with a brief discussion of the current landscape of educational policy. The discussion then “zooms in” and focuses on a set of particular educational policies in mathematics education: a brief history of the development of the NCTM *Standards* is presented, followed by a review of two efforts to investigate their impact. Zooming out once again, the discussion moves beyond the NCTM *Standards* and turns to investigations of the impact of other educational policies. Finally, the release of *Principles and Standards* is framed as a fresh chance to gain a better understanding of the role and influence of instructional policy documents. The chapter concludes with a review of the literature on professional development and with the theoretical framework that guided the research.

#### Educational Policy Landscape

During the past two decades, unprecedented energy and resources have been dedicated to the development and dissemination of policies aimed at reforming school education in general and mathematics education in particular. Such efforts are evidenced at all levels of the educational system. At the national level, the federal government has most recently and quite noticeably stepped into the educational policy arena with the



recent release of the No Child Left Behind Act of 2001. Professional organizations have produced and released subject-specific standards. Some aim to reform school curricula, teaching, and assessment (e.g., NCTM 1989, 1991, 1995, 2000; NRC, 1996); others put forth recommendations for teacher preparation and professional development (e.g., Conference Board of the Mathematical Sciences, 2001). States have followed suit, developing their own frameworks, standards, and corresponding assessments, in many cases attempting to align these with the visions and recommendations put forth in national documents (Council of Chief State School Officers, 1995). Responding to state efforts, local educational agencies have developed local policies that aim to interpret and support state standards, while simultaneously setting additional guidelines that reflect their particular needs and values.

It is important to note that the word “standard” has developed various, and often quite different, meanings and uses. For example, in some venues, a standard is an ideal to strive for but perhaps never reach; in others, a standard is the minimum acceptable level of performance or achievement. Similarly, “impact” can assume a variety of meanings, ranging from if and how various constituents have taken up the policy recommendations, to what changes, if any, can be attributed to the policy. “Success” of a policy can also assume a variety of meanings, including adequate dissemination of the policy, appropriate interpretation by its constituents, and faithful implementation of the policy recommendations. However, “success” most often refers to producing the changes intended by the policymakers.

The ever-growing role policy has attempted to play in efforts to reform school education in the U.S. is especially evident in the field of mathematics education. Indeed,

the release of the *Curriculum and Evaluation Standards for School Mathematics* (NCTM) in 1989 marked the first attempt by a professional organization to develop and articulate goals for school mathematics, and is attributed with launching what is today known as the “standards-based” reform movement in education. In the next discussion, the development of the NCTM *Standards* documents is outlined in order to provide an historical context.

### **Development of the NCTM Standards<sup>1</sup>**

The NCTM’s first significant foray into the policy arena can be traced back to 1980 to the release of *An Agenda for Action* (NCTM). Catalyzed to action by a growing body of evidence that there had been little improvement in school mathematics education over the past decade<sup>2</sup>, as well as by concerns about the Back to Basics Movement of the 1970s, the Council set out to provide a framework and a set of recommendations for guiding the future of school mathematics. *An Agenda for Action* set forth a new view of school mathematics, calling for the centrality of mathematical problem solving and for the use of technology to support mathematics instruction at all grade levels. More importantly, the document signaled to the world that the NCTM was now prepared to assume a central role in reforming mathematics education.

Mounting concerns in the early 1980s about the state of K-12 education in general, and mathematics education in particular, led to the release of several more

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<sup>1</sup> This account of the history of the NCTM *Standards* draws heavily on McLeod, Stake, Schappelle, Mellissinos, & Gierl, 1996.

<sup>2</sup> See, for example, Stake & Easley (1978).

reports, two of the most influential being *A Nation at Risk* (National Commission on Excellence in Education, 1983) and *Educating Americans for the 21<sup>st</sup> Century* (National Science Board, 1983). These two documents played a significant role in directing the nation's attention toward and setting the environment for school education reform. In response to these reports, both the Conference Board of the Mathematical Sciences and the U.S. Department of Education hosted conferences in November and December of 1983, respectively, to discuss the reports' implications for school mathematics. Both conferences independently culminated in a call for and endorsement of the development of a set of guidelines, or *standards*, for school mathematics.

Around the same time, committees within the NCTM began to recognize that in order to respond to growing demands for improved teaching and learning of mathematics in schools, they needed the Council to put forth a set of guidelines for school mathematics. The Research Advisory Committee was feeling increased pressure to respond to critics of mathematics reform; the Instructional Issues Advisory Committee felt compelled to step into the mathematics textbook publishing arena and take a stance on textbook selection; and the committee appointed to assess the impact of *An Agenda for Action* concluded that the document was too vague and that more specific guidelines were needed. These calls by various NCTM committees to create a set of standards for school mathematics were taken up by the NCTM Board of Directors in March 1984, resulting in a motion to appoint a task force to devise a plan for developing such standards.

By September 1985, a grant proposal for funding such an endeavor was completed and submitted to various agencies. When it became clear that external funding

would not be adequate, the NCTM set about funding the project internally. The motion to fund an effort to develop standards for school mathematics was passed unanimously at the March 1986 NCTM Board of Directors meeting. The Commission on Standards for School Mathematics was established to oversee the project. Writing group members and leaders were then selected to represent a range of constituencies, from classroom teachers to university faculty. The writing groups met and worked intensely during the summer of 1987 to produce a first draft. In October 1987, the NCTM widely distributed the draft and solicited feedback from the NCTM membership and from various focus groups. The writers met again the following summer, using feedback from the field to revise the draft and produce a final document. The final product – the *Curriculum and Evaluation Standards for School Mathematics* – was released on March 21, 1989. Realizing that a new vision of school mathematics curriculum necessitated a new vision of mathematics teaching and assessment, the NCTM later developed and released two more standards documents, the *Professional Standards for Teaching Mathematics* (1991) and the *Assessment Standards for School Mathematics* (1995).

The release of the *Curriculum and Evaluation Standards*, along with its 1991 and 1995 companion documents, influenced school mathematics education in several ways. First, soon after the release of the 1989 document, several states began to develop their own mathematics curriculum frameworks. Indeed, as of December 1994, 42 states had a state framework or content-related document in mathematics (Beaton et al., 1996). Moreover, most states attempted to align their documents with the NCTM *Standards* through similar emphases in content, use of content “strands”, division into grade bands, and overall vision. Second, some states began to require performance assessments for

teacher licensure in line with the recommendations of the 1991 *Professional Standards for Teaching Mathematics*. Third, in response to the vision and recommendations put forth in the *Standards*, the National Science Foundation (NSF) released a call for proposals to develop school mathematics curricula. NSF succeeded in funding several mathematics curriculum development projects, resulting in the creation of a number of “*Standards-based*” elementary, middle, and high school mathematics curricula. In addition, NSF funded many professional development and systemic change projects to develop teachers’ ability to enact *Standards-based* reforms in the classroom. Other subject-matter disciplines took notice of the policy work being undertaken by the NCTM and began to initiate similar efforts to develop standards in their own fields.<sup>3</sup> Finally, it has been argued that the *Standards* had some influence on research in mathematics education by focusing researchers’ attention on certain issues such as the role of communication in the mathematics classroom (Martin & Berk, 2001).

Due to their influence on the development of mathematics standards at the state level, the development of new school mathematics curricula, and the development of curriculum standards by other subject-matter disciplines, the NCTM *Standards* are often attributed with launching what is today known as the “standards-based” reform movement in education. From this standpoint, one could argue that the NCTM *Standards* have had a significant impact on U.S. education. However, this perspective assumes a particular conceptualization of an instructional policy document’s impact, where impact

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<sup>3</sup> See, for example, the *National Science Education Standards* (NRC, 1996). Such efforts were funded by grants from the U.S. Department of Education.

is traced in terms of how states, national funding agencies, and other professional organizations interpret and respond to the policy. In contrast, if impact of an instructional policy document is defined as influence on what teachers do in their classrooms and on what and how students are learning in classrooms, a different story emerges. In the next section, a review of a handful of studies that investigate the influence of the NCTM *Standards* on mathematics teachers and students is presented, revealing that in many ways the *Standards* have not had the impact envisioned by its developers and advocates.

### **Investigations of the Impact of the *Standards***

While the mathematics education field has proven itself to be quite capable of producing and disseminating numerous policies aimed at reforming school mathematics, it has yet to build a knowledge base for assessing the impact of these policies. To date, research has been grossly inadequate in establishing mechanisms that enable us to ascertain policy's impact and that help us to predict a policy's future success. Indeed, only recently have researchers in mathematics education begun to undertake a systematic, coherent effort to investigate the impact of instructional policy documents like the NCTM *Standards*. However, there have been a few isolated attempts to better understand what influence, if any, the *Standards* have had on school mathematics. Three of the most notable of such efforts are the 2000 National Survey of Science and Mathematics Education (Weiss, Banilower, McMahon, & Smith, 2001), the California Study of Elementary Mathematics (Cohen & Ball, 1990a, 1990b), and the Recognizing and Recording Reform in Mathematics Education project (Ferrini-Mundy & Schram, 1996). In the next section, the work of Weiss and her colleagues and the R<sup>3</sup>M project will be

described in detail in order to highlight the ways researchers have attempted to understand, trace, and characterize the impact of the NCTM *Standards*.

### **The 2000 National Survey of Science and Mathematics Education**

The 2000 National Survey of Science and Mathematics Education, along with its 1993 predecessor, represents one of the few attempts to determine the scope of awareness and impact of the NCTM *Standards*. The fourth and most recent in a series of surveys supported by the National Science Foundation, the 2000 Survey was developed to collect current information and identify trends in the following areas of K-12 mathematics and science education: teachers' background and experience; curriculum and instruction; and availability and use of instructional resources. The survey study, conducted by Iris Weiss and her colleagues at Horizon Research, Inc., was designed to address the following questions, among others:

- How well prepared are mathematics teachers in terms of content and pedagogy?
- What are teachers' goals for their mathematics instruction, and what activities do they use to meet these objectives?
- To what extent do mathematics teachers support reform notions embodied in the NCTM's *Principles and Standards for School Mathematics*?
- What are the barriers to effective and equitable mathematics education? (Weiss et al., 2001)

Conducting the 2000 Survey involved a careful and lengthy process of designing a sampling strategy, choosing appropriate school and teacher samples, and developing, field-testing, and then revising survey instruments over several iterations. Working from the questionnaires that had been used in the previous national surveys, the researchers solicited advice and feedback from an advisory panel of experienced researchers and

from several professional organizations in designing the updated instruments. The final survey was based on a national probability sample of K-12 mathematics and science teachers and schools in the fifty states and the District of Columbia. A total of 5,728 mathematics and science teachers participated in the study. Detailed information was collected from each teacher regarding a single, randomly chosen class (Weiss et al., 2001).

As one way to gauge the influence of the NCTM *Standards*, mathematics teachers were asked to characterize their own familiarity with the documents as “not at all familiar”, “somewhat familiar”, “fairly familiar”, or “very familiar”. Those teachers who indicated that they were at least somewhat familiar with the documents were also asked to indicate the extent to which they agreed with and were implementing the documents’ recommendations. The researchers found that over 60% of the teachers at each grade level reported being at least somewhat familiar with the NCTM *Standards*, with mathematics teachers at the secondary level (grades 9-12) being the most likely to report being familiar with the *Standards*. Of those teachers who reported being at least somewhat familiar with the *Standards*, approximately 75% of them at each grade band indicated agreeing with the documents’ recommendations. Furthermore, most of these teachers reported implementing the documents’ recommendations to at least a moderate extent: 82% of grades K-4 teachers, 84% of grades 5-8 teachers, and 74% of grades 9-12 teachers (Weiss et al., 2001).

In addition to soliciting information about teachers’ awareness of and alignment with the NCTM *Standards*, Weiss and her colleagues also sought to determine the influence of the documents on school-wide or district efforts to reform mathematics



instructional programs. School mathematics program representatives were asked to indicate the extent to which they agreed with statements about the impact of the *Standards* in their school or district, and to characterize the level of various school administrators' familiarity with the *Standards*. Approximately 50% of the schools sampled were reportedly engaging in school-wide efforts to reform their mathematics instruction in ways recommended by the *Standards*, and 55-59% of teachers in the schools were reported to be implementing the *Standards*. It is interesting to note, however, that only 30-33% of schools were indicated to have engaged teachers in discussions of the documents, less than half of the school districts had reportedly organized professional development opportunities for teachers around the *Standards*, and no more than 16% of districts had revised their evaluations of teacher performance to reflect the *Standards*. Moreover, fewer than half (38-45%) of the mathematics program representatives who were designated to respond to these items indicated that they themselves felt prepared to explain the *Standards* to their colleagues; these representatives even reported that the majority of principals, superintendents, and school board members in their school or district were also not well-informed about the *Standards* (Weiss et al., 2001). The data reported by the school representatives are surprising, for they seem to indicate that although most school administrators are not very familiar with the documents, and although teachers have not been provided with many opportunities to engage with and make sense of the documents, at least half of the schools and teachers surveyed have somehow made changes to their mathematics instruction that are aligned with the *Standards*. Thus, these findings suggest a shared phenomenon across school sites in which the majority of school mathematics educators had aligned

themselves with the *Standards* and are striving to implement them, although few had actually read or seen the documents.

The 2000 Survey also solicited data on teachers' classroom practices, including their objectives for their students' learning of mathematics, the types of instructional strategies they used to teach mathematics, and the types of classroom activities in which they engaged their students. Given that most mathematics teachers across the grades reported not only being aware of, but also agreeing with and working to implement the NCTM *Standards*, and given that so many schools reported being engaged in building-wide efforts to work toward the *Standards*, one might expect that teachers' descriptions of their instructional practices would in some way reflect the documents' recommendations. In terms of teachers' reported objectives for their students' learning, this seems to be the case. For example, the majority of mathematics classes (66-88%) were reported to heavily emphasize students' learning of mathematical concepts, problem solving, and mathematical reasoning, each of which could be identified as learning goals aligned with the *Standards*. And only 20-39% of mathematics classes were reported to heavily emphasize students' learning to carry out computations with speed and accuracy, an objective that is not greatly promoted in the *Standards* (Weiss et al., 2001).

However, teachers' reports of the instructional strategies they used on a daily basis to teach mathematics were not so well aligned with the documents' recommendations and vision. For example, Weiss et al. (2001) report that although approximately half of the teachers (46-56%) reported that they required their students to explain their reasoning and support their claims on a daily basis, no more than a third reported posing open-ended questions to their students, less than 15% reported having

students use multiple representations, and no more than 28% asked students to consider alternative solution methods on a daily basis. These “*Standards*-based” strategies would seem to support teachers’ self-reported priorities of developing students’ ability to reason and problem solve in mathematics, and yet they seem to be used infrequently. Rather, teachers’ reports of the instructional activities they used to teach mathematics were predominantly what would be considered more “traditional” methods. For example, one of the most frequent activities reported across the grades was answering textbook or worksheet questions. Teachers also reported having students practice routine computations and algorithms on a regular basis – approximately three-fourths of the mathematics classes included this on a weekly basis, and approximately one-third on a daily basis. And teachers reported that 68 – 88% of their most recent mathematics lessons involved lecturing. These reported strategies and activities do not seem well aligned with the learning goals teachers reported having for their students. Moreover, they paint a picture of K-12 mathematics instruction that has been corroborated elsewhere. (See, for example, Beaton et al., 1996.) In fact, in their cross-analysis of the four national surveys conducted to date, Smith et al. (2002) conclude that despite a great deal of attention to and interest in mathematics education reform, K-12 mathematics instruction has changed very little in the past decade. Thus, although most teachers reported knowing of and agreeing with the *Standards*, it is not clear what they mean when they report that they are working to implement them.

The 2000 Survey is significant in that it suggests widespread awareness of, agreement with, and efforts to implement the NCTM *Standards* in U.S. schools. Moreover, the survey results indicate that teachers and schools believe that they are

undergoing efforts to reform their mathematics instructional programs in the directions called for by the NCTM. However, like most survey studies, there are several limitations that should be considered. First, the study is comprised of self-report data: teachers and school representatives were asked to describe the extent to which their own beliefs and practices were aligned with the recommendations of a very prominent and well-respected organization. Thus, it is possible that some informants in the sample might have inflated their responses – either consciously or unknowingly – to indicate they were more aligned with the NCTM than they actually were. Second, it is not clear how respondents were interpreting the categories within each survey item. For example, teachers might have very different interpretations of what it means to be “somewhat familiar” with the *Standards* documents. To some, this might simply mean knowing of their existence; to others, this might mean having participated in a handful of workshops that addressed the *Standards*. Similarly, it is not clear how to make sense of the data regarding teachers’ level of agreement with or implementation of the *Standards*. What does it mean that 61% of middle school teachers reported agreeing with the documents, or that 59% of them reported implementing the recommendations “to a moderate extent”? Agreement could mean anything from concurring with some of the ideas and activities described in the documents to being passionately aligned with the underlying philosophy of teaching and learning mathematics. Similarly, implementation of the recommendations could range from arranging students in groups during instruction to significantly revising their goals for students’ learning of mathematics. Finally, data on the types of strategies and activities teachers reported using to teach mathematics do not help to clarify how teachers might be interpreting and implementing the *Standards*. While responses to some items

seem to indicate that teachers' mathematics instruction is aligned with the documents' recommendations, such as valuing student learning of mathematical concepts and problem solving, overall, teachers' characterization of their practice is dominated by traditional strategies and activities. Thus, although the 2000 Survey indicates widespread awareness of and agreement with the NCTM *Standards*, it provides a very hazy and limited picture of how the *Standards* are actually being interpreted and implemented by teachers and other constituents.

### **The Recognizing and Recording Reform in Mathematics Education Project**

One important study of how the first *Standards* documents were being taken up and interpreted by various constituents was The Recognizing and Recording Reform in Mathematics Education Project, or R<sup>3</sup>M. R<sup>3</sup>M was a multi-year project initiated by the NCTM in order to investigate and better understand how the *Standards* were being interpreted and implemented in schools across the country. A diverse team of twenty-two researchers took on the project, which was funded by a grant from the Exxon Education Foundation. The project aimed to accomplish the following goals:

- To measure the breadth and depth of knowledge about the NCTM *Standards* in various communities;
- To develop useful descriptions of teachers, classrooms, and children in settings where significant attempts at change in mathematics education, consistent with the NCTM *Standards*, seem to be underway;
- To describe the effects of this changed practice on classrooms and on children's learning of mathematics, in ways acceptable as evidence by teachers, policy makers, and the public;
- To increase understanding of the circumstances, forces, and situations in which change in the teaching and learning of mathematics occurs;
- To synthesize and disseminate insights and findings about contextual features that promote and hinder change in mathematics teaching and learning as envisioned in the NCTM *Standards*;

- To assist classroom teachers with the process of change in mathematics education by communicating descriptions of efforts to effect change. (Ferrini-Mundy & Graham, 1996, p. 5)

It is important to note that the project researchers did not set out to locate and portray implementation “success stories” but to investigate sites where serious efforts to reform mathematics instruction were reportedly being made. Schram and Mills (1996) explain, “It was not the project’s goal to identify exemplary sites for study, but rather to describe sites of mathematics reform where something could be learned about implementation or interpretation of the *Standards*” (p. 19).

In order to accomplish these goals, researchers solicited nominations of school sites where efforts were underway to reform mathematics instruction in alignment with the *Standards*.<sup>4</sup> The nominated sites were then invited to apply to participate in the study. After collecting questionnaires and conducting phone interviews, the researchers identified a final sample of seventeen school sites for investigation. Site visits of the seventeen schools were conducted between November 1992 and April 1994 by pairs of researchers who visited each site for two consecutive days. The researcher-pairs conducted both observations of mathematics classrooms and interviews with teachers, administrators, and students. To obtain additional data and gain a better understanding of some of the sites’ efforts, four sites were selected for an additional four-day visit. During this second visit, researchers interviewed students and conducted additional observations

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<sup>4</sup> Given that the project began in 1992, researchers were only considering schools’ efforts to interpret and implement the 1989 and 1991 *Standards* documents.

and interviews with teachers, administrators, and parents (Ferrini-Mundy & Graham, 1996).

In order to make sense of and describe the sites' efforts to implement the *Standards*, researchers developed five themes to guide their data collection and analysis. One such theme was the "mathematical vision" of each site – the site's goals for its mathematics instructional program and for students' learning of mathematics. The project researchers were interested in not only characterizing each site's mathematical vision but also determining in what ways, if any, their vision reflected the ideas and recommendations put forth in the *Standards*. Researchers identified five key features of the sites' "mathematical vision" of the reform, including a view that mathematics is more than just basic computational skills and that mathematics is for all students. The role and importance of basic skills was an important issue with which many teachers were grappling across sites. Teachers worried that an emphasis on the development of students' conceptual understanding through "hands on" activities might hinder their learning of basic computational skills and algorithms. Some teachers believed that basic skills needed to be developed first; others believed that students could develop basic skills through exploring and solving problems. The researchers conceded that it is difficult to determine what role, if any, the *Standards* documents themselves might have played in making this a salient issue for teachers. "It is not at all clear from the project in what way the actual text of the *Standards* documents either clarifies or contributes to the tension teachers feel with regard to this issue. Certainly the tendency seems to be to read the *Standards* (NCTM, 1989) as recommending a de-emphasis on basic skills, although the document clearly argues for basic skills development in several places... and only

recommends that there be ‘decreased emphasis’ on ‘rote memorization of rules’” (Ferrini-Mundy & Johnson, 1996, p. 113).

Another important theme that guided the researchers’ work was the “pedagogical vision” of each site – the site’s philosophy of and beliefs about learning and teaching mathematics. As with the sites’ mathematical vision, researchers were especially interested in what features of the *Standards* were reflected in the sites’ pedagogical visions. Researchers found that changes to the pedagogical features of the sites’ mathematics programs were much more prominent than changes to the mathematical features. The sites’ pedagogical visions shared several common features, including a shift to more student-centered instruction, increased opportunities for students to communicate about mathematics, and the sharing of authority for learning between teachers and students. Many teachers described attempting to change their role in the classroom to become more facilitative. However, it is again unclear as to how teachers had come to construct this new notion of their role, and what role the actual *Standards* documents might have played in this. “It was unclear precisely how teachers interpreted ‘facilitative’, and how and where in the *Standards* they might have come to see the emphasis on facilitating as a reformist stance” (Ferrini-Mundy & Johnson, 1996, p. 115).

In addition to identifying features of the sites’ mathematical and pedagogical perspectives, R<sup>3</sup>M researchers found that many sites had focused their reform efforts in a way that aligned with some aspect of their local context. For example, one secondary school site had adopted a program that was already being successfully implemented at a local university. Researchers labeled this alignment between a site’s contextual features and its choice of reform emphasis as *congruence*. One significant contextual feature was



teachers' dispositions toward reform. Researchers found that teachers' motivation to take on reform was directly related to their confidence. The more teachers felt recognized as mathematics professionals in their school, the more inclined they were to make changes to their practice. Another important contextual feature was time and opportunity for teachers to collaborate with other teachers. "Collaboration allowed teachers to construct their own consensus about what they would value and pursue in their efforts to improve mathematics teaching and learning – their own interpretation of the reform" (Ferrini-Mundy & Johnson, 1996, p. 118). Finally, the presence of a leader or specialist was found to be a crucial component for many of the school sites.

Finally, and perhaps of most interest for this study, the R<sup>3</sup>M researchers report that the *Standards* were being thought of and interpreted in a variety of ways. For example, teachers and administrators at some sites viewed the *Standards* as a comprehensive program, while others saw them simply as a menu of "add-ons". For example, some sites had chosen to adopt an entirely new mathematics curriculum that they felt was more aligned with the *Standards*, while other sites added on a new component, such as the use of projects, to an already existing curriculum (Ferrini-Mundy & Johnson, 1996). Teachers at Deep Brook Elementary School used the *Standards* as a resource guide by choosing mathematical tasks and designing their instruction in line with the five shifts advocated in the 1991 *Professional Standards for Teaching Mathematics* (Ferrucci, 1996). Some sites viewed the *Standards* as an "after the fact" means of validating efforts already underway to improve their mathematics programs. For example, a teacher from the East Collins High School site described the *Standards* as providing substantiation for their work. "When we first started PSML [The Perfect

Situation for Mathematics Learning], we had to prove to the parents that [it] was good, so the *Standards* were right there. And we were showing them this: 'Look, we are doing what's new, and what's out there, and what's good for your students.' And so we use the *Standards*" (Masingila, Tinto, & Johnson, 1996, p. 85). Similarly, teachers at Desert View High School had not used the *Standards* to help them decide on adopting a project from a local university. In fact, as one teacher explained, they did not begin to look at the documents until after they had developed a successful program. Thus, for some sites, the documents served more as sources of corroboration rather than guidance for their reform efforts. As Schram and Johnson (1996) explain, "Desert View illustrated the validating, rather than generative, influence of the NCTM *Standards*. Teachers interpreted the *Standards* as applicable in retrospect; they operationalized and affirmed the *Standards*' underlying concepts only after teaching mathematics through their own constructed projects" (p. 70).

The R<sup>3</sup>M study is significant in that it is one of a handful of studies that have attempted to understand how teachers and school administrators were implementing their understanding of the recommendations and ideas put forth in the 1989 and 1991 *Standards* documents. The study reveals that different interpretations of the *Standards* are possible, leading to different choices in reform emphasis, often aligned with the particular context of the site. However, it is important to recognize that the researchers entered the "scene" at a point at which many of the sites had already developed interpretations and conclusions about the *Standards* messages and were already in the process of making changes to their mathematics programs in light of these interpretations. This presents some limitations. First, the study sheds little light on *how* the teachers and administrators

had come to form their impressions of the *Standards*. For example, in describing the reform efforts underway at Deep Brook Elementary School, Ferrucci (1996) reports that the principal was “the vehicle through which the teachers became knowledgeable about the *Standards*” (p. 42). But how exactly did the principal become “knowledgeable” about the documents, and what exactly does this mean? What ideas and impressions about the documents did he develop, and why? Ferrucci reports that teachers also learned about the *Standards* by attending conferences and workshops. But what were these conference sessions and workshops like? And what exactly did teachers learn about the *Standards* from these experiences? Would teachers have developed similar understandings if they had read the document themselves?

Furthermore, by entering the scene “after the fact”, the researchers have based their characterizations of the sites’ interpretations of the *Standards* on an assumption that a site’s *implementation* of the documents is an accurate reflection of its *interpretation* of the documents. This may not be the case. It is easy to conceive of a site interpreting the *Standards* in one way, but due to various constraints or limitations, choosing to make changes that differ from, and perhaps even contradict, the interpretations they have drawn. I have observed such a phenomenon in a pilot study of a teacher’s practice that I conducted several years ago (Berk, 1998). Shirley<sup>5</sup>, a middle school mathematics teacher, was very familiar with the NCTM *Standards* and wanted her practice to reflect the vision of teaching put forth in the documents. Thus, during my observations of her seventh and eighth grade mathematics lessons, I was surprised to find that her instruction was quite

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<sup>5</sup> Pseudonym

traditional. Interviews with her gradually revealed that although she felt passionately about the ideas put forth in the *Standards*, she felt unable to realize its recommendations, due to various perceived constraints such as short class periods and a lack of resources. Thus, she was not “implementing” the *Standards* (and she was well aware of this herself), but this was not due to a misinterpretation of the documents on her part. Others have supported this contention that teachers often work under constraints (i.e., limited time and/or resources, demands from parents and administrators, lack of support for innovation) that force them to make compromises to their practice. The point is that it is dangerous to assume that the ways in which a single teacher or a school chooses to reform its mathematics instruction are an exact and faithful representation of the ways in which the teacher or school has come to understand the reform ideas. Although the R<sup>3</sup>M study makes a significant contribution to our understanding of the impact of the *Standards* in certain schools, further research is needed to shed light on how teachers and other school personnel actually interpret the documents, what particular ideas and understandings they construct, and why. Such knowledge could not only help us better understand why schools implement the *Standards* in different ways, but also help us better formulate educational policy documents like the *Standards* so that they are more likely to have the desired impact on school mathematics.

In this section, I have examined previous studies of the impact of the NCTM *Standards*. These studies provide valuable insights into the ways in which different constituents have interpreted and attempted to implement the recommendations put forth in the *Standards*. In the next section, I examine studies of the impact of educational policy more broadly, by moving beyond the *Standards* to other policy documents.

### Investigations of the Impact of Educational Policy

Gradually, educational researchers are recognizing that the two most common factors impugned for policy's lack of success – stakeholder interference and lack of resources– are inadequate in accounting for all instances of policy failure. Indeed, recent research has begun to uncover yet another key obstacle to the success of policy reforms: the ideas and understandings that stakeholders construct about reform. Spillane and Callahan (2000) conducted a study of district policy makers from nine school districts in Michigan to investigate what ideas these stakeholders had constructed about science education reform from the state's science standards, and to understand if and how their ideas about science reform influenced and were reflected in their implementation efforts. The researchers found that the ideas that district policy makers constructed about the science reforms caused them to either miss or misconstrue the intent of the policy, resulting in implementation efforts that were misguided or incomplete. From analyses of interview transcripts, Spillane and Callahan identified salient patterns in the ways district policy makers made sense of and talked about the science reforms. The most prevalent theme used by district policy makers to describe the science reforms was that of “hands-on science”. Further analyses of the district policy makers' talk of hands-on science revealed two underlying types of understandings of science reform ideas: *form-focused understandings* and *function-focused understandings*.

Form-focused understanding of science reforms entails seeing the central thrust of the reforms to be transforming pedagogical *forms* (i.e. instructional strategies, grouping arrangements, learning activities, students' work). District policy makers exhibiting a form-focused understanding of the science reforms focused on the importance of doing

more experiments and other hands-on activities as a means of accommodating multiple learning styles and increasing student interest and motivation. For them, modifying pedagogical forms was seen as the ends of science reform. Function-focused understanding of science reform ideas entails understanding the primary aim of the reforms to be transforming the epistemological and pedagogical *functions* of school science education – changing what counts as learning, knowing, doing, and teaching science in schools. District policy makers exhibiting a function-focused understanding of the science reforms would also advocate the use of more experiments in the classroom, but as an instrument for changing what it means to engage in scientific inquiry in schools. Pedagogical forms are not seen as the ends of science reform, but as the means to transforming what counts as knowing and doing science.

Spillane and Callahan (2000) found that most district policy makers constructed form-focused understandings of the science reforms and failed to construct function-focused understandings. Only 24% of district policy makers expressed function-focused understandings, which researchers further classified into one of three categories: 1) transforming science pedagogy; 2.) transforming students' understanding of the scientific process; and 3.) transforming science content. The type of understanding of science reform that district policy makers exhibited was found to be correlated with the nature of the reform efforts in which the district was engaged. District policy makers from low-implementation districts (districts whose reform efforts were primarily aimed at alignment of science topics) were three times more likely to exhibit form-focused rather than function-focused understandings of reform ideas. In contrast, the majority of district policy makers who expressed function-focused understandings of the science reforms

were from high-implementation districts (districts engaged in substantive efforts to re-conceptualize what counted as knowing and doing science in schools). Thus, district policy makers who used function-focused ideas to describe the science reforms were more likely to be engaging their district in substantive reform efforts, whereas those who solely or primarily used form-focused ideas to describe the science reforms were more likely to be engaging their district in surface-level reforms.

Like Spillane and Callahan's work, Hill's (2001) investigation of a district curriculum writing committee suggests another potential obstacle to successful policy interpretation and implementation – language. Hill observed the members of an elementary mathematics curriculum committee as they worked to translate the state's new mathematics standards into a mathematics curriculum framework for their district that would be aligned with the state standards and the state mathematics assessment. The committee, comprised entirely of K-5 classroom teachers<sup>6</sup>, began by adopting the state's ten overarching standards for elementary mathematics. They then pulled specific sub-objectives for student learning from both the state standards and from the district's mathematics curriculum, Saxon Mathematics, and mapped them onto the appropriate state standard. Finally, to each sub-objective, the committee attempted to assign the corresponding Saxon lesson or lessons, as well as the corresponding guideline(s) from the state mathematics assessment.

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<sup>6</sup> One staff member from the district's central office was assigned to the committee, but served primarily to support the teachers' work by ensuring that the teachers had the necessary financial support and meeting space.

In the end, Hill (2001) notes, the curriculum committee developed a district framework that, on the surface, seemed to be aligned with the state standards – it was based on the state’s ten overarching standards and even used many of the same terms as the state framework, and it included a statement of purpose that reflected the state’s perspective on mathematics teaching and learning. However, Hill reports that a closer examination of the committee’s work reveals several *disconnects* between the committee members’ ideas and those of the state policymakers, and between the two resulting documents. For example, although the Saxon curriculum and the state mathematics standards differ substantially in their views of what mathematics elementary students should learn, and how they should learn it<sup>7</sup>, the committee members did not discern any real inconsistencies between the Saxon curriculum and the state standards. Consequently, the committee members took the Saxon curriculum as an appropriate enactment of the state’s framework, often making decisions that conflicted with or missed the goals of the state framework. For example, the committee kept the state’s fourth grade sub-objective, “Construct, develop, and explain a variety of mental computation and estimation strategies” (p. 304). However, the Saxon lessons that the committee assigned to this sub-objective failed to address many mental computation strategies; the few strategies that were addressed were to be explicitly presented by the teacher and then practiced by the

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<sup>7</sup> For example, the state framework included standards for algebra and functions and for discrete mathematics, but the Saxon curriculum did not contain lessons on this content. The state standards called for students to develop conceptual understanding and to solve mathematics problems embedded in real life contexts; in contrast, the Saxon curriculum emphasized developing students’ proficiency in computational skills and included very few problems in real life contexts. The state standards called for teachers to engage students in more active reasoning on their own and in groups; the Saxon curriculum called for teachers to primarily present new material through demonstrations at the front of the room, and then have students practice.



students, rather than being developed by the students. Moreover, many of the lessons associated with this sub-objective did not even address mental computation or estimation strategies, but different representations or interpretations for the operations. In describing the committee's final product, Hill writes, "Saxon's fingerprints were everywhere on Oldtown's district standards; put simply, teachers interpreted the state standards on Saxon's terms" (p. 309). As a result, the district framework was more a reflection of the Saxon curriculum than the state framework, and so the state standards lost their potential to effect the changes that state policymakers had intended.

Hill (2001) posits that these disconnects were due to issues that arose from the use of language. Like most educational policies, the state mathematics standards used written words as the primary vehicle for their messages. Words are abstractions whose meanings must be concretized or derived by the reader. Thus, the cognition of the reader (or, policy constituent) plays a key role. Hill explains, "Put simply, actors' prior knowledge matters. Local policymakers (including street-level bureaucrats) will interpret novel guidance using their preexisting ideas about mathematics and instruction..." (p. 310). Moreover, words derive their meanings from the contexts in which they are used and from the communities in which they are received. Hill provides an example, explaining how the word "variance" has particular meanings, depending on whether the reader is a lawyer, a statistician, or a member of the general population. Similarly, many of the words used by state policymakers, such as "develop" and "concept", were specifically chosen to convey particular taken-as-shared meanings.

National and state mathematics reformers work in a milieu that has developed highly specific meanings for words used to describe student learning and, by extension, instruction. When they use the words "explore, discover, construct" to describe how students might learn mathematical

topics, for instance, they mean to imply students will build their own ideas about mathematics rather than “receive” wisdom from teachers. Considerable thought and years of research – in effect, professional development for policy leaders – has gone into elaborating the ideas and practices which words like “explore, discover, construct” are meant to imply, yet often, policies only show the fruits of these efforts, the finished product rather than the years of learning. In the final product, such words become convenient symbols for certain kinds of teacher and student interactions over content, but lack much context or tangible example of how teachers might apply these ideas. (p. 303)

An analogy to standard algorithms in mathematics comes to mind. Like the professional language used by state policymakers, standard algorithms in mathematics have been carefully developed over time to be accurate and efficient, to do (or “say”) exactly what they are intended to do. But as a result, standard algorithms tend to conceal the reasoning that lies behind them, that explains why they work and what they mean. Similarly, the particular terms used by state policymakers have been developed in the reform community over many years and through many debates. Because the teachers on the district curriculum committee had not been part of these debates, and because they were not members of the reform community, they were unlikely to interpret these words as the state policymakers intended. Rather, the teachers applied their own meanings to these words, meanings developed in their own community and based in large part on their experiences with the Saxon curriculum.

The specific words that comprise state standards often hold specialized meanings within reform and local communities, and these meanings often do not meet. State curriculum writers crafted their product using words such as “explore”, “construct”, and “understand” to signify certain expectations about student learning, and terms like “discrete math” or “algebra” to signify mathematical content to which they wanted children exposed. Yet locals, for the most part, did not have access to the reform communities that supplied particular meanings for those words. Instead, when curriculum committee members encountered these words, they understood and used them based on definitions supplied by more local subject matter communities, including some conventional student

curriculum materials and the professional development that accompanied it. In doing so, they often missed the instructional reforms state policymakers meant to imply. (p. 290-291)

Hill (2001) argues that the state policymakers and the committee members not only belonged to different professional communities, in which the same words held different meanings, but also were working within different mathematical communities. State policymakers and the district committee members were working from different understandings of mathematics, and of mathematical words, and these differences also caused disconnects. For example, the committee struggled to make sense of the state's discrete mathematics standard, which called for students to "use the concepts and processes of discrete mathematics to analyze and model a variety of real-world situations that involve recurring relationships, sequences, networks, combinations, and permutations" (p. 306). Not fully understanding what was meant by discrete mathematics, the committee interpreted the standard to be primarily about the use of models and real-world situations. Consequently, the committee decided to cut the discrete mathematics standard completely, arguing that it was embedded in the other standards. Hill reports that uncertainty about the meanings of particular mathematical terms often led the committee to turn to a dictionary, and this sometimes led to them developing and then working from misinterpretations. For example, the committee members debated the meaning of the word "algorithm". Although they located an appropriate definition in the dictionary, they misinterpreted the definition, concluding that an algorithm meant writing a number sentence vertically instead of horizontally. Hill concludes, "Because their communities held different meanings for the same words, reformers and local

policymakers spoke past one another, failing even to engage in the most rudimentary of debates about effective mathematics instruction or desired student learning” (p. 306).

In this section, I have looked beyond studies of the impact of the NCTM *Standards* to the impact of other policy documents. Two important investigations of the efforts of different constituents – district policymakers and elementary school teachers – to interpret instructional policy documents (state standards in science and mathematics, respectively) were examined. Results from these studies support the arguments made earlier in this chapter that constituents’ interpretations of policy can influence the nature of their efforts to implement the policy recommendations. In the next section, I return to a consideration of the NCTM *Standards*, focusing now on the most recently released document, *Principles and Standards for School Mathematics*.

### ***Principles and Standards for School Mathematics***

Recognizing that any set of standards needs to be regularly examined and updated to incorporate what has been learned from research and practice, as well as to reflect the demands of an ever-changing society, the NCTM initiated a process to revise the *Standards* with the establishment of the Commission on the Future of the *Standards* in 1995. This process culminated in the development of a new standards document, *Principles and Standards for School Mathematics*, released in April 2000.<sup>8</sup> *Principles and Standards*, which builds on and extends the vision put forth in the NCTM’s original

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<sup>8</sup> For a detailed account of the development of *Principles and Standards*, see Martin and Berk (2001) and NCTM (2000).

*Standards* documents, embodies the most current thinking, research, experience, and expertise of a wide variety of groups invested in mathematics education. The document features ten standards addressing the mathematical content and processes that students should know in each of the pre-kindergarten through grade twelve years.

*Principles and Standards* offers the field a fresh chance to better understand the role and influence of instructional policy documents. How might we develop genuine professional development opportunities for teachers to engage with and make sense of *Principles and Standards*? I now turn to a brief review of the literature on professional development for guidance.

### **New Directions for Professional Development**

For many years, the classic teacher “workshop” has been the most prevalent form of professional development available for teachers (Garet, Porter, Desimone, Birman, & Yoon, 2001; Little, 1993; Loucks-Horsley, Hewson, Love, & Stiles, 1998). University courses and education conferences have also served as typical avenues for teachers’ professional development. These forms of professional development emerged from a process-product model for teacher development in which teaching was conceptualized as a set of specific skills and behaviors (or, processes) that, when implemented correctly, result in students’ learning (the product) (Sprinthall, Reiman, & Thies-Sprinthall, 1996). Professional development experiences designed within this training model share several characteristics: they tend to be highly structured, relatively short in duration, led by an expert or experts, and aimed at transmitting particular skills or knowledge to participating teachers.

Researchers and teacher educators have begun to recognize the limitations and contradictions posed by these traditional forms of professional development (Garet et al., 2001; Little, 1993; Loucks-Horsely, et al., 1998). First, teachers often report finding traditional in-service workshops of little value for their continued learning (Smylie, 1989). Second, the assumptions about teaching and learning that underlie workshops and other traditional forms of professional development are in direct opposition to the assumptions on which current reforms are founded. Workshops convey a static view of knowledge as discrete components, a view of teaching as direct transmission of these components through telling and demonstrating, and a view of learning as acquisition of these components through listening and observing. In contrast, current reforms put forth a view of knowledge as dynamic and connected, a view of teaching as facilitating and supporting students, and a view of learning as active construction of knowledge by the learner through connecting new ideas to one's past experiences.

Little (1993) reviewed four relatively recent professional development projects that depart from the training model and instead are designed to help prepare teachers to meet the challenging demands of current reforms. From her review of these alternative forms of professional development, Little distilled six principles that can guide future professional development projects:

1. Professional development offers meaningful intellectual, social, and emotional engagement with ideas, with materials, and with colleagues both in and out of teaching.
2. Professional development takes explicit account of the contexts of teaching and the experience of teachers.
3. Professional development offers support for informed dissent.
4. Professional development places classroom practice in the larger contexts of school practice and the educational careers of children.

5. Professional development prepares teachers (as well as students and their parents) to employ the techniques and perspectives of inquiry.
6. The governance of professional development ensures bureaucratic restraint and a balance between the interests of individuals and the interests of institutions (pp. 138-139).

Other researchers have posited similar lists of principles for “effective” professional development (Clarke, 1994; Loucks-Horsley & Matsumoto, 1999).

Unfortunately, the research on the effects of different forms of professional development is scarce (Wilson & Berne, 1999). In particular, we know little about the connection between professional development and student learning. Loucks-Horsley and Matsumoto (1999) provide some reasons for this. Building on a model initially developed by Guskey and Sparks (1996), Loucks-Horsley and Matsumoto propose that establishing clear links between teachers’ professional development and their students’ learning requires an examination of the complex relationships between many features of the school system, including the school culture, the knowledge and commitment of school administrators and the community members, and the school, district, and state policies and standards for curriculum and assessment. In particular, Loucks-Horsley and Matsumoto (1999) note that we do not know enough about the connections between teachers’ learning and students’ learning. As a consequence, it seems many professional developers have aimed to set less ambitious goals and aim for desired changes in teachers’ dispositions, knowledge, and/or classroom practice.

Despite a paucity of empirical evidence, a few studies have been conducted that examine various *forms* of professional development. I now turn to a brief review of two particularly promising forms.

## Study Groups as a Form of Professional Development

A great deal of the professional development literature focuses on the forms and structures of various professional development efforts, and their effectiveness. In recent years, there has been a growing realization that traditional *forms* for professional development (i.e., the typical one-day workshop) are insufficient, especially when the goal is to help teachers understand and embrace reforms like those proposed by the NCTM (Corcoran 1995; Darling-Hammond 1995; Lewis 1997; Little 1993). Miles (1995) describes the current situation as quite bleak:

Let's frame the issue in extreme terms. A good deal of what passes for "professional development" in schools is a joke – one that we'd laugh at if we weren't trying to keep from crying. It's everything that a learning environment shouldn't be: radically underresourced, brief, not sustained, designed for "one size fits all", imposed rather than owned, lacking any intellectual coherence, treated as a special add-on event rather than as part of a natural process, and trapped in the constraints of the bureaucratic system we have come to call "school". In short, it is pedagogically naïve, a demeaning exercise that often leaves its participants more cynical and no more knowledgeable, skilled, or committed than before. (p. vii)

Consequently, there is a new focus on alternative vehicles for professional development that take into account what we know about the challenges of reform, the characteristics of effective professional development, and adult learning. One such alternative is the study group. A study group is a group of teachers and other interested parties who voluntarily agree to meet on a regular basis over an extended time to study a particular issue in depth. Study groups are designed to build community among its participants, challenge participant's beliefs, engage them in deep and critical thinking about their practice, and integrate theory and practice (Birchak et al., 1998). Study groups are founded on the same theory of learning embodied in the reform movement – a theory that rejects the



“transmission” model of learning and instead assumes that children should be active participants in and take responsibility for their own learning. Study groups make the same assumptions about teachers as learners, and in this way, they validate teachers as professionals.

The use of teacher study groups as a means of professional development has been studied extensively (Boggs, 1996; Clair, 1998; Jones, 1997; Matlin & Short, 1991). Study groups provide a supportive environment in which teachers can collaboratively explore and discuss issues and ideas of interest to them (Boggs, 1996; Jones, 1997). Participating in a study group encourages teachers to “think through their own beliefs, share ideas, challenge current instructional practices, blend theory and practice, identify professional and personal needs... it’s a strategy for empowering teachers to be active thinkers about their work” (Matlin and Short, 1991, p. 68). Study groups have proven effective in helping teachers deepen their knowledge (Clair, 1998), learn and experiment with new strategies and teaching models (Makibbin & Sprague, 1991; Matlin & Short, 1991), become more explicit about their beliefs (Birchak et al., 1998; Matlin & Short, 1991), and implement school improvement goals (Boggs, 1996). Teacher participation in study groups can also lead to changes in classroom practice and have a positive impact on student achievement (Birchak et al., 1998; Makibbin & Sprague 1991; Matlin & Short 1991).

### **Lesson Study: A Type of Study Group**

Lesson study, a particular use of study groups as a means for professional development, has received increased attention in recent years. The TIMSS video study

compared 8th grade mathematics teaching in the U.S., Germany, and Japan. Japan's teaching was of special interest due to its students' high achievement in both mathematics and science. Stigler and Hiebert (1999) concluded that in Japan, teachers' participation in lesson study is a key factor in improving classroom teaching. In lesson study, groups of teachers meet regularly over the course of several months to a year to collaboratively design, implement, reflect on, evaluate, and then improve classroom lessons. Stigler and Hiebert contend that a similar system should be developed in the U.S. "Lesson study, as it works in Japan, is fully consistent with what we know about how to improve complex cultural activities like teaching, and it works, simultaneously, toward improving both teaching and teachers' knowledge and skills" (p. 150). Since the improvements teachers make are curriculum-based, lesson study enables teachers to make improvements that align with local and national standards. Furthermore, lesson plans developed through lesson study allow teachers to link theory with practice.

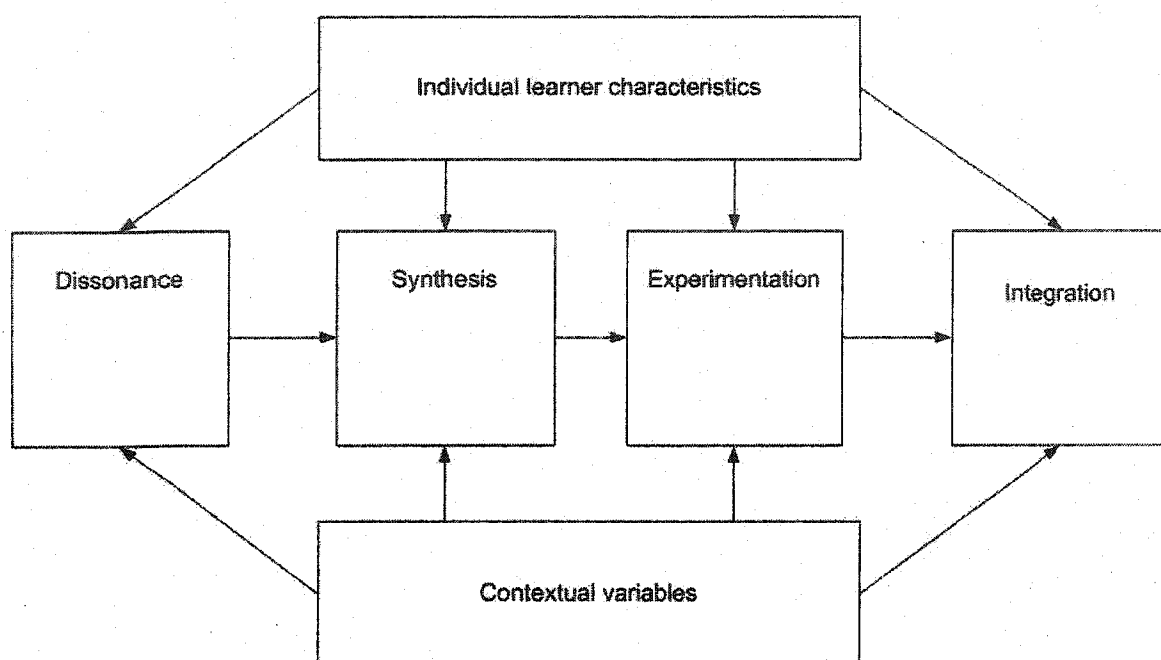
Lesson study has the potential to solve what has been identified as a major problem in U.S. education, and that is the gap that exists between educational policymakers and classroom practice. Teachers are caught in a persistent dilemma: Although they frequently receive advice and recommendations on how to change their teaching, and they know that some of these changes would probably benefit their students, they also lack the learning opportunities needed to study the recommendations, decide which changes would be meaningful, and learn how to implement them... Lesson study offers an alternative that will appeal to the teachers caught in this difficult position. Lesson study shifts the key for effective teaching from on-the-fly decision making during the lesson to careful investigation and planning before the lesson... Thus, what starts as a vague and impractical suggestion from educational experts gets transformed, through lesson study, into an improvement in classroom practice. (p. 155-156)

### Theoretical Framework for Professional Development

This research study draws on Ross and Regan's (1993) constructivist model for teachers' professional development. (See Figure 1.) The model consists of four stages, each of which involves teacher reflection as a fundamental process. Building on the work of Schön (1987), the researchers define *reflection* as "an individual process containing two elements: metacognitions (awareness of the strategies, theories, and feelings that underlie one's professional problem solving) and appraisals (judgments about performance)" (Ross & Regan, 1993, p. 92). In the first stage in the model, *dissonance*, teachers become more explicit about their own beliefs, knowledge, and classroom practice by considering a new idea in terms of their past experiences as teachers and learners. They begin to develop dissatisfaction with some aspect of their teaching or their students' learning and an awareness of a more promising alternative. Ross and Regan characterize teachers' reflection at this stage as primarily *recollective*, in that teachers are striving to interpret and decode the new idea in relation to, or through recollecting, past experience. In the *synthesis* stage, teachers strive to resolve discrepancies between their current understanding and the new ideas about teaching and learning, resulting in "mutual adaptation of current practice with selected elements of the valued alternative" (p. 93). Teachers' reflection at this stage is *anticipatory* in that they are thinking ahead to how they might interact differently in certain situations. In the *experimentation* stage, teachers begin to implement some piece or adaptation of the new idea and reflect on its effects. Finally, in *integration*, teachers modify their understanding of the new idea and begin to anticipate how their new perspective might be further explored.<sup>9</sup>

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**Figure 1. Constructivist Model of Professional Development**



Ross and Regan's (1993) model assumes that individual characteristics of teachers can influence these professional growth processes. In particular, teachers' knowledge, beliefs, and past experiences are important variables, as they constitute the substance of teachers' reflections. If reflection involves becoming explicit about and examining one's knowledge and beliefs, then what teachers know and believe will in part determine the "content" of their reflections. For example, teachers who have well developed understandings of what constitutes a proof in mathematics will have different cognitive resources available to them than teachers who have weak or incomplete understandings of proof. Similarly, if learning involves examining one's past experiences

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<sup>9</sup> Ross and Regan (1993) define professional development as "changes in understandings, affects and actions that increase effectiveness in a role" (p. 91). Given this definition, their model for professional development can also be considered as a model for teacher learning, broadly construed.

in relation to new ideas, then the types of experiences teachers have had will in part determine teachers' reactions to and understandings of a new idea. For example, teachers who have had a wide range of experiences in different school settings, with different student populations, and using different mathematics curricula will have a broader base to draw from than teachers who have only taught in one school, with one population of students, or using only one mathematics curriculum.

The model also assumes that contextual features can influence the development process (Ross & Regan, 1993). Contextual features include a school or district's norms for teaching and for professional growth, the level of support for innovation from administrators and community, and the physical and financial resources available to teachers. For example, the resources available in teachers' schools or districts can afford or constrain their ability to experiment with and integrate new ideas and approaches. Teachers may be in a stage of questioning their stance on technology use in instruction and ready to try adopting a new approach. But if instructional technologies are not valued or simply not available in their school or district, then teachers' abilities to move to experimentation and integration are hampered. Similar arguments can be made about the physical and temporal structure of teachers' schools. Teachers who are limited to 40-minute class periods face different obstacles than those who teach on a block schedule and have longer class periods. The influence of contextual features is supported by findings from the R3M study, which suggest that the reform direction that teachers and administrators in a school pursue was influenced in part by the site's contextual features (Ferrini-Mundy & Schram, 1996).

Working from this model for professional development, Ross and Regan (1993) construct a theoretical argument for the potential for teacher learning afforded by *professional sharing*, defined as “the reciprocal exchange of reports of professional experience by practitioners” (p. 93). They argue that sharing stories of one’s experiences involves making one’s beliefs and values public and open for scrutiny. By responding to their peers’ questions about and reactions to their stories, practitioners will become more explicit about their own stances and will begin to identify gaps and limitations in their thinking, allowing for dissonance. Furthermore, listening to the stories of their peers provides practitioners with opportunities to become aware of and begin to consider alternative ways of thinking and acting. In these ways, professional sharing supports teachers in the dissonance stage in the model.

Ross and Regan (1993) hypothesize that “discussion might encourage learners to elaborate, revise, and integrate their understandings with other views because in social situations we must satisfy others, as well as ourselves, of the reasonableness of our positions” (p. 93). In other words, sharing their professional stories in a social setting encourages teachers to analyze and possibly adapt their current thinking in light of new ideas under consideration. Moreover, in reacting to each other’s professional stories, teachers will offer advice and share perspectives that might help the speakers identify ways of reconciling inconsistencies in their thinking. Ross and Regan also posit that professional sharing might provide teachers with the emotional support needed to persist in critically evaluating their understandings. In these ways, professional sharing can support teachers in the synthesis stage.

By fostering a shared sense of collaboration and unity, and a shared recognition that change is difficult, professional sharing might help teachers become more willing to engage in the experimentation stage. Developing expectations that teachers' efforts to experiment should be shared with the group might also support teachers in this stage. Finally, Ross and Regan conjecture that hearing stories of other teachers' attempted adaptations will provide additional data from which teachers can begin to make generalizations about their own experiences, thereby supporting them in the integration stage.

How might this model apply to my research? I hypothesized links between Ross and Regan's conception of *professional sharing* and my predictions about the nature of teachers' discussions. First, I anticipated that professional sharing would make up a substantive portion (if not all) of teachers' discussions of the document. Teachers, like all learners, draw on their current beliefs and experiences in order to make sense of new ideas such as those presented in the document. Since the teachers' study of the document would take place primarily in a public forum (the study group sessions), I anticipated that teachers' attempts to interpret the document's vision and recommendations in light of their own experiences would manifest themselves in the form of publicly shared "teaching stories". In other words, professional sharing would be a subset (perhaps not proper) of the teachers' discussions of the document. Given these parallels, I hypothesized that analysis and discussion of the document would provide a fruitful site for teachers to experience dissonance and engage in synthesis. By drawing on their beliefs and experiences to make sense of the document, and having to communicate their beliefs and experiences to the rest of the group, teachers would have opportunities to

become more aware of and explicit about what they really think and do. In comparing their classroom practice to the idealized vision described in the document, teachers would be likely to experience some dissatisfaction with their practice. Moreover, listening to the ideas and experiences of a diverse group of teachers would provide teachers with alternatives to consider. By engaging in lesson study with their partner, teachers would have a context in which to engage in experimentation. By piloting new ideas with a peer and by sharing their lesson study experiences with the rest of the group, teachers would have opportunities to receive feedback and further adapt their ideas, allowing for the potential for integration.

In the next chapter, the context of the study, including recruitment of participants and the design of the professional development experience, are described in detail. I then describe the research methodology employed.



## CHAPTER 3

### CONTEXT AND METHOD

This chapter presents the context of the study and the research methodology employed. I begin by describing the research site. Unable to identify an appropriate environment in which I would be able to investigate my research questions, I had to begin by creating such a site. This entailed designing and then seeking funding for a professional development project for middle school mathematics teachers. The goals and components of the professional development project are described, including the process by which participants were solicited and selected. The research design – interpretive case study – is then elaborated. Finally, I describe the methods and instruments used to collect data, and the techniques used to analyze the data.

#### Establishing a Research Site

One test of teachers' professional development is its capacity to equip teachers individually and collectively to act as shapers, promoters, and well-informed critics of reforms. (Little, 1993, p. 130)

#### Designing the Professional Development

Recall that the purpose of this research was to investigate the interpretations and ideas mathematics teachers developed about *Principles and Standards* and about mathematics education more generally when given an opportunity to read and analyze the document, and to trace what impact such an experience might have on the teachers' beliefs, priorities, and practice. Thus, pursuing these questions meant first identifying and

gaining access to a site in which mathematics teachers were reading and working to make sense of *Principles and Standards*. Such an environment might be a university course, a professional development program, or a study group of teachers at one school, but it needed to possess certain features. First, the nature of teachers' engagement with the document needed to be serious, sustained interaction that was teacher-directed rather than expert-driven. Many instructional policy documents, such as state standards and frameworks, consist primarily of lists of benchmarks and mathematics topics, with very little elaborated text. In contrast, *Principles and Standards* presents elaborated discussions of critical issues in school mathematics education and builds arguments for its recommendations. It also provides many examples of mathematics tasks and classroom vignettes designed to illustrate the NCTM's vision for school mathematics. Thus, I anticipated that developing an understanding of the document would require serious reading and analysis. Moreover, I was not interested in what interpretations teachers might form after listening to an "expert" describe his or her understanding of the document. Rather, I wanted to investigate the ideas teachers would develop by engaging firsthand with the recommendations and ideas put forth in the document – by reading and mulling them over, grappling with them, talking through them with others, comparing them to their past experiences and current beliefs, knowledge, and priorities, and considering the implications for their own classroom practice. This also necessitated that such an experience would need to put the document at the forefront. A university course or a "one shot" workshop in which an overview of the document was just one of many competing goals would not provide the opportunities I wanted teachers to have. Second, duration of the experience was important, for similar reasons. Given the unusual nature of

this policy document, teachers would be apt to develop incomplete or superficial understandings of the document if provided with minimal time to engage with the document. Grappling with issues such as the role of equity and technology in mathematics education, or with the document's vision for how students' understandings of algebra build across the grades, would require ample time and varied interactions with the document.

In addition to needing a site that possessed particular features, I also had requirements for what the intended content or goals of such an experience for teachers should be. I wanted to study an environment in which teachers were being pushed to develop more than just an awareness or surface level understanding of the document. Enabling teachers to leave the experience able to report facts about the document's structure such as, "The document consists of six principles and a set of ten standards", or broad statements about the document's underlying philosophy such as, "All students should be expected to learn challenging mathematics" would be far from sufficient (and not particularly interesting). Rather, I wanted to investigate an environment in which teachers were being encouraged to develop deeper understanding of the issues and of the NCTM's stance on them. Perhaps most importantly, I did not want conversion to be a goal. I did not want the teachers to feel pressured to "buy into" the document's recommendations and vision. Rather, I wanted teachers to be encouraged to question and to feel safe in disagreeing with the document.

To locate a site that had the necessary features, I spoke with colleagues, reviewed recent literature on professional development and on educational policy, and conducted searches on the Internet for efforts that involved engaging mathematics teachers with

*Principles and Standards*. My search proved fruitless: my colleagues were not aware of any such efforts past or present, and I found nothing described in the literature or on the Internet that would meet my needs. The NCTM's Professional Development Academies – two to three-day workshops designed to help teachers develop awareness of and gain exposure to *Principles and Standards* – were underway by this time. However, the structure and duration of the Academies would not allow for the type of in-depth, serious study of the document by teachers that I hoped to investigate.<sup>1</sup>

Unable to locate any such efforts, I had to begin by creating the environment I needed in order to pursue my research questions. One of the first decisions I had to make was in regard to the participants. I considered two options: working with a group of teachers who taught mathematics at a single school but a wider range of grade levels, or working with a group of teachers from several schools who taught mathematics at the same grade level or grade band. The first option appealed to me for several reasons. The teachers would share a common school context, similar goals and priorities for their students' learning of mathematics, and (potentially) the same mathematics curricula. They would also already be acquainted with each other. As a result, conducting classroom observations would be more convenient for me, and it would be easier to design the experience to meet the group's particular needs. Furthermore, given that the teachers would be able to continue to interact with each other outside of and after the experience, the potential for impact on the teachers might be greater. However, working with only one school would mean making a decision about which teachers would

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<sup>1</sup> For example, the Fall 2003 brochure for the NCTM Academies describes their goal to be "to clarify NCTM's *Principles and Standards for School Mathematics*, so you can return to your classroom reenergized and confident in implementing the ideas" (<http://www.nctm.org/academy/sumfall03.pdf>, p. 2).

participate, a decision that might be the purview of school administrators with agendas different than my own. Would every teacher be required to participate, regardless of interest and motivation? Or, would the decision be made based on the administrator's perception of the teachers' effectiveness and performance? For example, an administrator might want to allow only "low performing" or only "high performing" teachers to participate. Furthermore, depending on the size of the school and the number of participating teachers, the range of grade levels at which mathematics was being taught might necessitate studying several grade band chapters in the document. It would also mean that I would need to design activities that were aligned with and appropriate for a wider range of grade levels.

The second option – working with teachers from different schools but the same grade level or grade band – also posed advantages and disadvantages. Teaching the same or consecutive grades would mean that the teachers might share some common experiences, strategies for, and ideas about teaching mathematics to a particular student population. In addition, it would mean that the group could focus their time and effort on a single grade band chapter of the document. This would also be easier for me, in terms of designing activities aligned with the grade band. However, by coming from different schools, I realized that the teachers would need more time to get acquainted with each other and develop trust and comfort interacting with each other. They might be teaching in very different school settings, with very different types of mathematics curricula and student populations, and under very different types of constraints and expectations from parents, administrators, and the wider community. Finally, there would be logistical challenges such as conducting classroom observations within several different schools

and finding a common meeting place for the study group sessions that was convenient to all participants.

In the end, I decided that the diversity that working with teachers from different schools would allow was more a strength than a disadvantage. I hypothesized that such diversity might result in richer discussions of the document, as teachers from different settings would potentially bring a greater variety of perspectives to the table. It would also allow me to pursue some hypotheses about the links between different teacher characteristics (certification level, teaching experience, mathematics curricula used) and the different interpretations they developed about the document. In addition, I only wanted to work with teachers who volunteered to participate. Given that very little work of this kind had been done at the time, it seemed to me that trying to work with a mix of teachers, some of whom were motivated and interested and some of whom were not, would only complicate matters. Thus, I hoped to avoid the situation in which a school principal had mandated that all teachers of mathematics participate in my project, regardless of interest, a situation that seemed more probable in the case of working with a single school. Recognizing that providing school support and situating teachers' work in their own practice are recognized as important components of effective professional development (Clarke, 1994; Garet et al., 2001; Little, 1993; Thompson & Zeuli, 1999), I strongly encouraged interested teachers to apply with another teacher from their school. In this way, participants would have a school-based partner with whom they could interact outside of the study group in considering the implications of the document for their own school setting and classroom practice.

My next decision was to design the experience specifically for middle school mathematics teachers. I had two primary reasons for doing so. First, in talking with others about my plans and in reading the relevant literature, it became clear that middle school mathematics teachers were especially in need of professional development designed specifically for them. For example, results from the Third International Mathematics and Science Study [TIMSS] reveal that the mathematics performance of students in the U.S. steadily worsens as they leave elementary school and move into the middle grades (Beaton et al., 1996). In fourth grade, U.S. students scored above the international average in mathematics; in eighth grade, they performed below the international average. This drop in mathematics performance, from above average in the fourth grade to below average in the eighth grade, occurred in no other TIMSS country besides the U.S. Moreover, the recognition of the middle grades as a distinct level of schooling is a relatively recent phenomenon; consequently, the majority of past professional development efforts have focused primarily on addressing the needs of elementary (kindergarten through grade eight) and high school mathematics teachers, to the neglect of the specific needs and interests of middle school mathematics teachers. Second, I chose to work with middle school mathematics teachers due to personal preferences. I have always been especially interested in the “big ideas” – rational number concepts and operations, proportional reasoning, and linearity – that characterize most middle school mathematics curricula. My affinity for these mathematical ideas was further strengthened through my work on the *Connected Mathematics Project* at Michigan State University. This experience enabled me to become very familiar with, and increasingly fascinated by, this curriculum as well as other middle school mathematics curricula. Furthermore,

during my work as a research assistant on the writing of *Principles and Standards*, I was able to observe and occasionally participate in the development of the standards for the middle grades. As a result, I grew increasingly curious about how teachers would react to and interpret Chapter 6 in the document, the chapter for grades six through eight.

In designing a professional development project for middle school mathematics teachers that would serve as the site for my research, my decisions were guided by my beliefs about teaching and learning mathematics, my perspective on professional development and my knowledge of the literature on effective professional development and teacher learning, and by my research questions. To pursue my questions, I needed to structure the project in a way that would enable teachers to build a sustained community in which they could collaboratively discuss and analyze the document. In such a community, teachers should feel ownership over the conversations and their work. In order to analyze each other's interpretations and ideas about the document, teachers would need to feel safe enough to share their concerns, questions, and ideas publicly. As a community, they would also need to develop what Lord (1994) calls "critical collegueship" – the disposition, confidence, and ability to push each other's thinking, to question each other's ideas in productive ways. The role of the "leader" or expert in such a community would be to support the teachers' work by helping the group establish productive norms and by facilitating the discussions, asking questions in both whole group and individual settings that would assist teachers in making sense of the document. Given my review of the literature, I chose the design of the professional development experience to be a teacher study group. As I described in Chapter 2, the study group as a



vehicle for professional development coincided with my goals and vision for the project and with my perspectives on learning, teaching, and professional development.

To provide teachers with additional opportunities to reflect on and deepen their understanding of the document outside of the study group sessions, I planned for teachers to maintain a dialogue journal with me. A dialogue journal is a journal in which two persons (usually a teacher and a student) engage in a one-on-one written dialogue. The student writes either a prompted or open-ended journal entry and the teacher responds. In the next entry, the student composes a reply to the teacher. In this way, a private, written communication develops between the teacher and each student. Many studies have investigated the use of dialogue journals as a means of encouraging teachers to become reflective practitioners (Bacon 1995; Heichel & Miller 1993; Holten & Brinton 1995; Lee & Zuercher 1993). Writing enables people to organize and clarify their thoughts and to formulate, internalize, and evaluate concepts and make connections between them. Research has shown that writing also fosters improved communication between both a teacher and individual students and the teacher and the class as a whole (Borasi & Rose, 1989). Thus, I planned to ask participating teachers to respond in writing to prompts that would support them in reflecting on the readings and clarifying and organizing their ideas. I would then respond to their journal entries, asking questions that would push them to think more deeply about certain issues, probe their understanding, and encourage them to clarify their thinking. Ideally, teachers would then compose a reply to my response. In this way, the dialogue journals would enable me to establish a one-on-one dialogue with each teacher.

While I was able to turn to the literature to make informed choices about the *form* my professional development project should take, I was not as fortunate when it came to planning the *curriculum* of the professional development. As I discussed in Chapter 2, only recently has the professional development field begun to recognize the importance of specifying the what, and not just the how, of teacher learning. Those who have begun to more explicitly address the role and implications of the content of professional development have focused on more familiar domains of teacher learning, such as mathematics content knowledge or pedagogical knowledge. Few (if any) efforts have been undertaken to design and implement a professional development experience in which the content to be studied was an instructional policy document like *Principles and Standards*. Thus, in designing and choosing the types of activities that would best support teachers in making sense of the document, I had to rely on theoretical arguments that linked my design choices to my beliefs about learning and teaching, rather than relying on empirical results to guide my decisions. For example, because I believe that learning has both a social and an individual component, I wanted teachers to have multiple opportunities to make sense of the document not only in collaboration with their group members, but also on their own in more private settings. Thus, in addition to planning for whole group discussions of the document during the study group sessions, I set up a listserv that would enable the group to interact and hold discussions between study group sessions.

To support the teachers in making connections between the ideas they encountered in the document and their past experiences and current thinking, I wanted to provide opportunities to ground what might be very abstract discussions of the document

in a more familiar and authentic setting. Consequently, I planned to engage teachers in grounding their consideration of the ideas and recommendations put forth in the document in an analysis of “records of practice” – classroom mathematics tasks, students’ work, and cases of mathematics teaching. In addition, I asked each teacher-team to conduct a lesson study around one of their mathematics lessons. In these ways, teachers could explore the ideas that emerged from their study of the document within genuine teaching practices (i.e., planning and implementing lessons, analyzing mathematical tasks and students’ work on those tasks).

The professional development project’s original design included eleven, three-hour study group sessions, scheduled approximately twice a month from February to June 2001. About midway through the project, several of the teachers expressed an interest in continuing to meet into the summer in order to complete their study of the document. Nine of the original fourteen teachers and I met for an additional five study group sessions, ranging from three to six hours long. Thus, by the completion of the project in August 2001, nine of the teachers and I had participated in sixteen study group sessions for approximately 55 contact hours.<sup>2</sup>

We spent the first study group session getting to know each other. I presented a brief summary of the document’s development and structure, and had the teachers view a videotape that provided an overview and introduction to the document. We also discussed the details of the project and completed paperwork. The central activity of the remaining study group sessions was discussion and analysis of selected readings from *Principles*

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<sup>2</sup> Hereafter I will refer to the original group of fourteen teachers as the “full group”, and the nine teachers who continued into the summer as the “summer group”.

*and Standards*. Each study group session was facilitated by one of the school-based teacher pairs, whose responsibility was to initiate and then guide the discussion. The leaders of a session would often begin by reading aloud a particular passage in the document, commenting on their interpretation of and reaction to it, and then soliciting reactions from the rest of the group. As the discussion ensued, teachers would often share stories about their own experiences, students, classroom, building, and district. At the end of each session, the group would collectively choose the readings for the next session. All reading was done outside of the group, on the teachers' own time. As was mentioned earlier, I established an electronic listserv to allow the teachers to ask questions of each other and discuss ideas outside of the study group sessions.

To discourage the group from viewing me as the expert whose responsibility was to translate the document for them, I decided at the outset to not be the "leader" of any of the sessions after the first, and I purposefully participated as little as possible in the early sessions.<sup>3</sup> As the teachers grew more comfortable with and trusting of each other, and more confident in their abilities to make sense of the document without my input, I gradually took a more active role, pushing them to reflect more deeply and to take a more critical look at the document.

Originally, I had planned for teachers to focus their study on Chapters 2, 3, and 6. Recall that Chapter 2 sets out six principles – Equity, Curriculum, Teaching, Learning, Assessment, and Technology – that should guide the design of any school mathematics instructional program. Chapter 3 provides an overview of each of the ten standards, and

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<sup>3</sup> I suspected that this would be challenging for the teachers at first, some of whom might be hoping that I would play a more directive role. To my surprise, from the beginning the group had little difficulty engaging in and sustaining rich discussions of their readings from the document.

sketches the developmental trajectory of each standard from pre-kindergarten through grade twelve; Chapter 6 elaborates each of these standards for grades six through eight. At my suggestion, the group began by reading Chapter 1, which introduces the document and describes its purposes and the NCTM's vision of school mathematics. About midway through the project, the full group decided to read and discuss Chapter 8, which describes how the vision of mathematics education put forth in the document might be achieved. The summer group became increasingly interested in what the Writers had proposed for the grades immediately preceding middle school. Consequently, individual teachers volunteered to study pieces of Chapter 5, which sets out standards for grades three through five, and then report to the whole group on their assigned reading.

Although discussion and analysis of the document was our primary focus, it was not the sole study group activity. At times, I brought in a mathematics task for the group to work on that corresponded to the standard we were reading. The group would work on the task either individually or in small groups, then discuss and reflect on the task as a whole group, focusing not only on ways to solve the problem, but also on how the task fit in with our readings, and how it might be used with students. We also analyzed various records of practice: student work, teaching cases, and videos of mathematics teaching. We spent the majority of one session comparing *Principles and Standards* to the Michigan Curriculum Framework for Mathematics. Table 3 provides a summary of the activities and readings for each study group session.

**Table 3. Overview of the Study Group Sessions**

	Date	Length	Document Readings	Math Task	Other Activities
1	2/15/01	3 hrs	N/A	No	Introductions, overview
2	2/27/01	3 hrs	Chapter 1; Equity Principle	No	No
3	3/5/01	3 hrs	Algebra	Algebraic proof of the Pythagorean relation	No
4	3/13/01	3 hrs	Teaching Principle	No	Analyzed student work (concept maps)
5	4/19/01	3 hrs	Number & Operations	Rational number task	No
6	4/24/01	3 hrs	Number & Operations	No	Big Ideas
7	5/3/01	3 hrs	Problem Solving	No	Discussion of teaching case
8	5/10/01	3 hrs	E-Examples	No	Exploration of the electronic examples
9	5/17/01	3 hrs	Geometry	Network problem (Discrete math)	Comparison to Michigan Curriculum Framework
10	5/31/01	3 hrs	Reasoning & Proof; Chapter 8	Checkerboard Problem (Reasoning)	No
11	6/14/01	3 hrs	Chapter 8; Technology Principle	No	No
Summer meetings begin					
12	6/23/01	6 hrs	Measurement	Angle measurement task	Analysis of videotaped mathematics lesson; Big Ideas
13	6/28/01	3 hrs	Communication	Orchard Problem (Problem solving)	Discussion of videotaped lesson
14	7/12/01	4 hrs	Data Analysis & Probability	No	Big Ideas; Discussion of teaching case
15	7/25/01	5 hrs	Connections	Sea Tac Problem (Representation)	Big Ideas; Design e-example lesson
16	7/27/01	4 hrs	Representation	No	Big Ideas

### Soliciting Funding

Given the ambitious goals I had for teachers and given the time demand I knew would be required of them, I wanted to be able to provide participants with a stipend to recognize and reward such work. This meant pursuing funding. I decided to apply for a grant from the Dwight Eisenhower Higher Education Professional Development program, a competitive grant program in which state departments of education receive federal monies specifically earmarked for mathematics and science professional development of practicing K-12 teachers.<sup>4</sup>

One condition of applying for an Eisenhower grant was partnership with (and partial funding from) one of the state's mathematics and science centers. I chose to approach the Capital Area Science and Math Center (CASM) because it served school districts closest to Michigan State University (MSU). CASM is a consortium of K-12 school districts in five counties (Ingham, Eaton, Clinton, Ionia, and Shiawassee) in central Michigan. At the time of the study, CASM was serving 43 school districts, which included 42 middle/junior high schools in both rural and urban settings. The center's primary efforts were directed toward designing, coordinating, and implementing teacher professional development programs. The following were among CASM's goals for the professional development of mathematics and science teachers:

- Providing and sponsoring teacher-centered, content appropriate, best practice learning experiences centered around state and national standards, with provisions for follow-up support; and
- Providing opportunities for educators to move from passive recipients and consumers of professional development to active participants in collaboration with their colleagues.

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<sup>4</sup> The program consists of several grant categories, including the development and restructuring of pre-service teacher preparation programs.

Thus, my desire to design and offer a professional development experience in which teachers would be active participants in a study of a national standards document fit well with CASM's goals at the time.

Moreover, my timing seemed to be perfect. The Michigan Department of Education had been increasing pressure on the state math and science centers to augment efforts to provide professional development for mathematics teachers in the state (Personal communication with Jan Eberhardt and Pete Vunovich, June 2000). In response to this, CASM had organized and hosted a meeting of mathematics teachers, curriculum directors, and specialists from both public and private, non-profit schools in order to better understand mathematics teachers' professional development needs and to explore the possibility of holding a regional mathematics conference. At this meeting, teachers indicated that they would be interested in conferences that helped increase awareness and use of *Principles and Standards*. Furthermore, they expressed a desire to determine how *Principles and Standards* meshed with their district needs and with the *Michigan Curriculum Framework*.

Given our similar goals, as well as evidence from the community that there was a need for the type of experience I hoped to provide and study, a partnership between myself and CASM seemed timely. With the help of colleagues at Michigan State University, I made contact with the director of CASM. Over the course of about one month, we met several times to discuss and plan the project. During these meetings, we focused primarily on practical issues such as advertising the project, soliciting participants, and negotiating CASM's financial contribution; I was primarily responsible



for the project's design, format, and curriculum, although they and others were available for advice and feedback.

I submitted the grant proposal on June 30, 2000. Although the original grant solicitation indicated that applicants would be notified sometime in August, I did not receive notification that my proposal would be funded until late October. Due to this and to challenges in negotiating and receiving approval to do research involving human subjects from two different universities, I decided to postpone the project, pushing back the start date from October 2000 to February 2001.

### **Soliciting and Selecting Participants**

In order to solicit participants, I designed a brochure and application packet that announced and described the project and invited teachers to apply. Approximately 370 brochures were mailed in December 2000 to teachers of mathematics in grades sixth through eighth across the five counties served by CASM.<sup>5</sup> Interested teachers were asked to apply with a partner from their school, and to complete and submit an application providing information regarding their certification level and education, teaching experience, familiarity with the NCTM *Standards*, goals for their practice, and their interest in the project.

Twenty-five applications were received by the posted deadline, four from teachers with no school-based partner.<sup>6</sup> (During this time, I also had phone conversations and

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<sup>5</sup> Several mailing lists of both individual teachers and of K-8 and junior high schools were obtained from colleagues at Michigan State University. Approximately thirty brochures were returned due to an incorrect mailing address.

email correspondence with several other interested teachers who eventually chose not to apply due to various reasons.) From this initial pool, I set about selecting fourteen teachers. The primary criteria for selection were a clearly expressed commitment and interest in the project and an identified school-based partner. In addition, I worked from the hypothesis that the discussions would be richer, and that teachers would be able to learn more from each other, if they came with different experiences and backgrounds. Thus, I sought to achieve diversity along several factors – certification level (K-8 or 7-12), years of teaching experience, familiarity with the NCTM *Standards*, school demographics, and the mathematics curriculum they were using. I also solicited advice from colleagues at MSU who had experience working with local teachers from various districts. The final group consisted of fourteen middle school mathematics teachers – six school-based pairs and two individual teachers in different school districts who agreed to be partners.<sup>7</sup> Table 4 and Table 5 display the diversity among the final group of participating teachers along several dimensions.

After selecting the group, I composed and sent letters to every applicant informing them of my decision. Fortunately, every admitted teacher accepted my invitation to join the group and was able to meet on the pre-scheduled date of the first

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<sup>6</sup> The low response rate can be attributed to a variety of factors – the timing (advertised in December, to begin in February), the duration of the project (five months, eleven three-hour sessions), and the strong recommendation to apply with a school-based partner, to name a few.

<sup>7</sup> Carla is the only middle school mathematics teacher in her district; in her application, she made a strong case for needing opportunities to engage with other middle school mathematics teachers. Kayla's partner decided not to apply at the last minute, leaving her with no time to secure a new partner in her school. Both Carla and Kayla use the *Connected Mathematics Project* (CMP) curriculum. Thus, although they worked in different districts, they agreed to serve as each other's partners.

study group session.<sup>8</sup> The following provides a brief description of each of the seven teacher-teams who participated in the project<sup>9</sup>:

Dara and Suzy: Dara and Suzy teach mathematics in a public middle school in an affluent suburban district in mid-Michigan. Their building uses the *University of Chicago School Mathematics Project* (UCSMP) curriculum. At the time of the project, Dara and Suzy were both teaching sixth grade mathematics.

Brian and Mindy: Like Dara and Suzy, Brian and Mindy teach mathematics in a public middle school in an affluent suburban district in mid-Michigan. Their building had adopted the *Connected Mathematics Project* (CMP) curriculum several years ago. At the time of the project, Brian was teaching sixth and seventh grade mathematics; Mindy was teaching eighth grade mathematics.

Joyce and Monique: Joyce and Monique teach in a public middle school in a rural district in mid-Michigan. Their building uses the Saxon mathematics curriculum. At the time of the project, Joyce was teaching eighth grade mathematics and Monique was teaching seventh and eighth grade mathematics.

Janelle and Lana: Janelle and Lana teach in a public K-12 charter school in the heart of a large city in mid-Michigan. The building has no set mathematics curriculum; thus, mathematics teachers choose their own materials, often borrowing from more than one curriculum series. During the year of the project, Lana was teaching eighth grade mathematics and Janelle was teaching sixth grade in a self-contained classroom.

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<sup>8</sup> This date – February 15, 2001 – had been stated in the advertisement.

<sup>9</sup> From this point on, all names (of teachers, school districts, etc.) are pseudonyms.

Edgar and Tim: Edgar and Tim teach in a public middle school in a suburban region outside a large city in mid-Michigan. Sixth and seventh grade mathematics teachers use the CMP curriculum. In eighth grade, they switch to *Integrated Mathematics*, a more traditional textbook published by McDougal Littell (a Houghton Mifflin Co.). During the year of the project, Edgar was teaching eighth grade mathematics and Tim was teaching seventh grade mathematics.

**Table 4. Characteristics of Participating Teachers**

	Teaching Experience			Certification			Familiarity with the <i>Standards</i>			Gender	
	0-2 yrs	3-7 yrs	8+ yrs	K-8	7-12	Other	Not at all	Somewhat	Very	M	F
Brian			X	X				X		X	
Mindy	X				X			X			X
Janelle			X	X	X		X				X
Lara		X			X			X			X
Carla			X	X				X			X
Kayla			X	X					X		X
Tim		X			X		X			X	
Edgar		X		X	X			X		X	
Callie			X	X				X			X
Mimi			X			X <sup>b</sup>		X			X
Joyce			X		X			X			X
Monique			X	X				X			X
Dara		X		X			X				X
Suzy	X			X			X				X
Subtotal	2	4	8	9	6	1	4	9	1	3	11
Total		14			16 <sup>a</sup>			14			14

<sup>a</sup>Janelle and Edgar held both K-8 and 7-12 certification. <sup>b</sup>Mimi had a BS in engineering. She did not hold a teaching certificate.

Carla and Kayla: Carla teaches in a public K-8 school in a small, rural district in mid-Michigan. Carla is the only middle school mathematics teacher in her district; thus, she teaches sixth, seventh, and eighth grade mathematics in her building, using the CMP curriculum. Kayla teaches in a public middle school in a rural region in mid-Michigan. At

the time of the project, Kayla was teaching seventh and eighth grade mathematics using the CMP curriculum.

Callie and Mimi: Callie and Mimi teach in a private Catholic K-8 school in the heart of a large city in mid-Michigan. Their building had just adopted the CMP curriculum the year of the project. Callie was teaching sixth grade mathematics; Mimi was team-teaching eighth grade and managing administrative duties.

**Table 5. Characteristics of Participating Teachers' Schools**

	Curriculum			School		
	Reform	Traditional	Other	Urban	Suburban	Rural
Brian	X				X	
Mindy	X				X	
Janelle			X	X		
Lara			X	X		
Carla	X					X
Kayla	X					X
Tim	X				X	
Edgar		X			X	
Callie	X			X		
Mimi	X			X		
Joyce		X				X
Monique		X				X
Dara			X		X	
Suzy			X		X	
Subtotal	7	3	4	4	6	4
Total		14			14	

### **Research Design**

The use of case study methodology in educational research has been employed for at least the past thirty years and is especially popular today (Merriam, 1998; Patton, 1990). However, despite its prevalence, there is some ambiguity as to what a case study is and how case study research is conducted. Indeed, "case study" has been defined in multiple ways in the literature. Some researchers define case study as the *process*

undertaken in case study research. Wilson (1979) describes a case study as a process in which one “tries to describe and analyze some entity in qualitative, complex and comprehensive terms not infrequently as it unfolds over a period of time” (p. 448); Yin (1994) defined it as “an empirical inquiry that investigates a contemporary phenomenon within its real-life context” (p. 13). In contrast, other researchers have classified case studies in terms of their *final product*. For example, Wolcott (1992) views a case study as “an end-product of field-oriented research” (p. 36) and Stake (2000) identifies a case study as both the process and product of investigating a case. Finally, case study has also been defined in terms of the *unit of investigation*. Miles and Huberman (1994) refer to a case study as “a phenomenon of some sort occurring in a bounded context” (p. 25). Stake (1995) elaborates on this distinction, referring to it as a “case” rather than a “case study”:

The case could be a child. It could be a classroom of children or a particular mobilization of professionals to study a childhood condition. The case is one among others... An innovative program may be a case. All the schools in Sweden can be a case. But a relationship among schools, the reasons for innovative teaching, or the policies of school reform are less commonly considered a case. These topics are generalities rather than specifics. The case is a specific, a complex, functioning thing. (p. 2)

Merriam (1998) notes that underlying each definition is a notion of demarcating boundaries around what will be investigated. “I have concluded that the single most defining characteristic of case study research lies in delimiting the object of study... [I] see the case as a thing, a single entity, a unit around which there are boundaries. I can ‘fence in’ what I am going to study” (p. 27). Stake (2000) also highlights this: “A doctor may be a case – but his doctoring probably lacks the specificity, boundedness, to be called a case” (p. 436). In defining case study as “intensive, holistic description and

analysis of a single unit or bounded system” (p. 12), Merriam interweaves the notions of case study as process, product, and unit of analysis.

Merriam (1998) provides a different classification by differentiating case studies by their overall intent. A *descriptive case study* presents a very detailed description of the case; for this reason, these types of case studies are particularly beneficial in providing data about phenomena around which little research has been conducted. The intent of an *interpretive case study* is twofold: it not only provides rich description of the case but also uses the data to develop hypotheses or a typology that can be used to explain and further explore the phenomenon under study. Finally, evaluation case studies aim to go one step further; their intent is to not only provide rich description and develop possible explanations, but also to evaluate and make judgments about a particular phenomenon.

Despite some disparity in defining “case study” and a variety of case types, researchers tend to agree that case study research is characterized not by the types of methods employed but by the kinds of questions under investigation (Merriam, 1998; Patton, 1990). Merriam (1998) argues that case study research is appropriate when the researcher is interested in pursuing “how” and “why” questions, when the goal is to identify significant factors characteristic of the phenomenon and to understand their interaction, and when it is difficult to separate the important variables from their context.

The case study offers a means of investigating complex social units consisting of multiple variables of potential importance in understanding the phenomenon. Anchored in real-life situations, the case study results in a rich and holistic account of a phenomenon. It offers insights and illuminates meanings that expand its readers’ experiences. These insights can be construed as tentative hypotheses that help structure future research; hence, case study plays an important role in advancing a field’s knowledge base. (Merriam, 1998, p. 41)

Stake (2000) presents a similar argument. "Case study is not a methodological choice but a choice of what is to be studied. By whatever methods, we choose to study the case" (p. 435).

For this research study, I adopt Merriam's (1998) definition of a case study as "intensive, holistic description and analysis of a single unit or bounded system" (p. 12) and employ an interpretive case study design. The phenomenon I wanted to investigate was mathematics teachers' interactions with and attempts to interpret and make sense of an instructional policy document, in the context of a study group. To better understand this phenomenon, I chose to study a particular instance, or case, of it. More specifically, I limited my investigation to a particular group of mathematics teachers working around a particular policy document. In this sense, both the study group as a whole, as well as the individual members of the study group, may be considered cases. Through the cases, I aim to provide thick description of the teachers' discussions and the ideas they developed by studying the document, and to develop hypotheses that might explain why particular teachers developed particular interpretations.

### **Data Sources**

Data on teachers' developing ideas about the document and about mathematics education more generally were collected from multiple sources. The primary source of data was the study group sessions. Other sources of data included teachers' dialogue journals, their applications to the project, interviews with teacher-teams, listserv discussions, classroom observations, and belief surveys. Discussion of the data collection



begins with the first available data source, namely the teachers' written applications to the project.

### **Applications to the Project**

The applications that teachers had submitted in order to be considered for the project were collected; a photocopy of each application was made as a backup. (See Appendix for a copy of the application form.) The applications provided information about participants' teaching experience – the number of years spent teaching, the grade levels taught, and their level of certification. In addition, teachers were asked to describe their awareness of and past experiences with the NCTM *Standards*, their professional needs and interests, and their reasons for applying to the project.

I was especially interested in teachers' responses to the following questions on the application form:

Question 2: Discuss your current awareness/knowledge of NCTM's *Standards* documents. (This can include the previous standards and/or the most recent document, *Principles and Standards for School Mathematics*.) Which documents, if any, have you seen? Read? Worked with? What is your sense of them? Have you participated in other professional development experiences that focused on NCTM's *Standards*? If so, please describe these experiences.

Question 3b: In my mathematics instruction, I want to improve the following areas:

Question 3c: My students need a better understanding of the following mathematical concepts:

Question 4: Discuss why you are interested in participating in the (MS)<sup>2</sup> project. What do you hope to gain from your participation? (Application)

Teachers' responses to these particular questions not only helped me make decisions about whom to admit to the project; they also provided baseline data on teachers'

entering knowledge of the *Standards*, their priorities for their mathematics instruction, their perceptions of the mathematical needs of their students, and their goals for themselves as participants in the study group.

### **Study Group Sessions**

The study group sessions were the principal forum in which participating teachers shared their reactions to and ideas about their readings of the document, and worked collaboratively to make sense of the document's recommendations and messages. Thus, the study group sessions served as the primary source of data. Each of the sixteen study group sessions was audio- and videotaped, and transcribed.

In addition to discussing readings from *Principles and Standards*, teachers participated in a variety of supporting activities during the study group sessions. They solved mathematics tasks, analyzed student work, read cases of mathematics teaching, and viewed videotaped mathematics lessons. Conversations around these activities were captured on the audio- and videotapes. I also collected all related documents from these activities. Finally, during the study group sessions, I also took field notes, making note of particular comments that teachers made about the document, about the study group, about the other study group activities, or about themselves as teachers and learners.

### **Dialogue Journals**

As discussed earlier, participating teachers were asked to maintain a dialogue journal. Teachers were provided with prompts to respond to that were aimed at supporting them in reflecting on the readings and clarifying and organizing their ideas. I

carefully read and then responded to teachers' entries, pushing them to think more deeply about certain issues, probing their understanding, and asking for clarifications. Although it was not required, teachers were encouraged to compose a reply to my response and to follow up on ideas they had written about in earlier entries.

Over the course of the project, teachers were asked to respond to eight journal prompts. The first six prompts were assigned to teachers during the eleven originally planned sessions. The last two prompts were assigned during the summer sessions. Some journal prompts aimed to solicit teachers' reactions to and ideas about particular readings from the document or about the document as a whole. Other prompts asked teachers to reflect on the study group and what they were learning through their participation. Given that teachers were completing all journal entries, in addition to the readings and the lesson study work, on their own time, it is not surprising that from time to time teachers failed to submit a journal entry when it was due. Whenever this occurred, I followed up with the teacher and requested that the entry be submitted as soon as possible. Unfortunately, despite frequent requests and reminders from me, some teachers never responded to particular journal prompts, resulting in missing data. Table 6 displays the journal entries that were completed by each teacher.

All of the teachers' dialogue journal entries, and my responses to them, were collected and photocopied. The teachers' journal entries were then typed into their own Word files. The files were named in a way that distinguished the author of the entry and the journal number. Documents containing teachers' occasional responses to my replies were named in a way that would distinguish them as "follow-up" responses to a particular

journal prompt. For example, the file “Journal Carla\_3 Resp” contains Carla’s response to my response to her third journal entry.

**Table 6. Teachers’ Completion of Dialogue Journal Entries**

	J1	J2	J3	J4	J5	J6	J7 <sup>b</sup>	J8	# Completed by Teacher
Brian	X	X	X	X	X	X	X	X	8
Carla	X	X	X	X	X	X	X	X	8
Dara	X	X	X	X	No	X	--	--	5
Edgar	X	X	X	X	X	X	--	--	6
Joyce	X	X	X	X	X	X	X	No	7
Janelle	X	X	X	X	X	X	X	X	8
Kayla <sup>a</sup>	X	X	X	X	No	--	--	--	4
Callie	X	X	X	X	X	X	X	X	8
Lara	X	X	X	No	X	No	No	No	4
Mimi	X	X	X	X	X	X	X	X	8
Monique	X	X	X	X	X	X	X	No	7
Mindy	X	X	X	X	X	X	--	--	6
Suzy	X	X	X	X	X	X	--	--	6
Tim	X	X	X	X	X	X	No	No	6
# Completed by Journal	14	14	14	13	12	12	7	5	111 entries and responses

<sup>a</sup>Kayla had dropped out of the study group by the time the sixth entry was assigned. <sup>b</sup>Journals 7 and 8 were assigned during the summer meetings, when only nine of the fourteen original teachers were still participating.

### **Listserv Discussions**

To avoid losing momentum between study group sessions, which were at times scheduled two or more weeks apart, I set up and administered an electronic mailing list of all participating teachers and myself. I hoped that this listserv would provide a forum outside of the study group sessions for the participants to continue their discussions and share questions and ideas that arose while reading the document. These on-line conversations would also provide additional data on teachers’ developing ideas about the document and about mathematics education reform more generally. Moreover, their ways

of participating (or not) on the listserv might provide further insight into the roles they were taking on in the study group and their potential to learn from the study group experience.

Initiating and participating in listserv discussions was completely voluntary. The listserv existed solely to support our work as a study group, and so I encouraged the participants to work with me to determine what ways, if any, it might do so. For example, in addition to maintaining dialogue outside of the study group sessions, the teachers and I decided to use the listserv to share additional resources such as articles, instructional materials, and websites, and for planning purposes such as preparing for the next study group session and scheduling school visits and observations. Every listserv message was saved and stored in a folder on my computer. In addition, a paper copy of every listserv message was printed and filed.

### **Classroom Observations**

From the very first night the group met, teachers began to volunteer details about the context of their work – specifics about their classroom practice, their students, the mathematics curricula they were using, their school building, and their administration and parents. Given my interest in understanding the interplay of the professional development experience of studying *Principles and Standards* with the teachers' knowledge, beliefs, values, and instruction, teachers' self-reports of their classroom practice were of particular interest to me. Such revelations tended to arise naturally during whole-group discussions of the document, as teachers compared the vision of teaching and learning put forth in the document to their own classrooms and considered the implications of the

document's recommendations for their own practice. Teachers also shared information about their particular school building, students, and mathematics classes during conversations outside of the study group discussions, in email correspondence, and in journal entries. Self-reports of classroom practice ranged from broad qualifiers, such as, "I mean it seemed like... [the document is] kind of reconfirming what you already do or what you already thought" (Monique, Second Study Group Session) to very targeted images of a particular component of their instruction, such as, "I have a unit called 'Families of Functions', and so kind of what I do is we, they [students] are all assigned their own function and we have something like  $\frac{5}{x}$  and we have quadratics and cubics and linear functions (Lara, Third Study Group Session).

While teachers' descriptions of their own teaching and school contexts can be intriguing and informative, they are not necessarily a completely accurate representation of their actual practice (Schifter & Simon, 1992). Teachers' perceptions of their practice are influenced by a variety of factors, including their beliefs about teaching and learning, their understanding of mathematics, and their self-efficacy as teachers (Cohen, 1990; Cohen & Ball, 1990a, 1990b). Moreover, I suspected that teachers might initially feel uncomfortable admitting to practices that were not aligned with (their understanding of) practices advocated by the NCTM, and thus they might be more prone to portray their practice as more "*Standards-based*" (whatever that might mean in their own minds) than it really was – either knowingly or unwittingly. Thus, I decided that I would need to visit teachers' schools and classrooms in order to see firsthand what their schools, students, and mathematics instruction were like.

School visits and observations of one or more lessons were conducted of every participating teacher except Mimi.<sup>10</sup> Observations were scheduled beforehand at a time that was mutually convenient for the teacher, and that would enable me to observe one or more lessons and meet and talk with the teacher either before or afterwards. Whenever possible, I scheduled a school visit at a time that was convenient for both teachers in a particular teacher-team. This enabled me to maximize efficiency by not only meeting with their administrators and staff, but also visiting and observing both of the teachers' classrooms during a single extended visit to their school. Initially I planned to observe each teacher on at least two different occasions. In this way, I hoped to minimize the chances of visiting and observing the teacher on an atypical day. I also suspected that some teachers might be tempted to prepare a special lesson and show me what they thought I wanted to see, and that this might be less likely to occur on two separate occasions. However, severe scheduling and time constraints made visiting and observing each of thirteen different teachers on two different occasions in different locations in the state very difficult. Consequently, I managed to observe most teachers on only one occasion, approximately midway through the project. During my observations, I took extensive field notes. Whenever possible, I also collected materials (handouts, worksheets, etc.) relevant to the lesson(s) I observed.

To minimize the chances of observing an atypical lesson, I worked with the teachers to schedule my visit on a day that they felt had a high probability of being a typical day for them. This involved, for example, avoiding the days before and after

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<sup>10</sup> Recall that Mimi had assumed a more administrative role in her building during the year of the project and thus she was not responsible for teaching any one class of mathematics. However, during my visit of her partner, Callie, Mimi did attend class that day and acted as a teacher's aide to Callie.

holidays, the days when teachers were being observed and evaluated by their superiors, and the weeks proceeding and following school mandated student testing. To minimize the possibilities that some teachers might be tempted to “put on a show” for me, all of the teachers were informed and frequently reminded that the intent of the classroom observations was not to measure the extent to which their instruction was aligned with the recommendations and ideas put forth in *Principles and Standards*. I would not be evaluating their instruction or judging their teaching expertise. Rather, teachers were assured that the purpose of the observations was to help me better understand the particulars of their schools and their students. I told teachers that I wanted to meet, see, and hear their students as they learned mathematics; I wanted to see how their classrooms were structured and equipped; I wanted to thumb through their mathematics textbooks and other materials. Most importantly, I wanted to witness a typical mathematics lesson in their classroom. As such, I urged them to not prepare a “special” lesson for those days I would be observing. I frequently explained to teachers that the better I understood what it was like to be them, teaching in their classroom, to their particular students, the better I could understand where they each were “coming from” and the better I would be able to interpret and understand how and why they viewed the document and its recommendations in certain ways. I also made sure to delay scheduling observations until approximately midway through the project so that I would have had time to build rapport and trust with each teacher. The more comfortable they felt with me, the more likely they would be willing to teach a typical lesson during the observation.



### **Mid-Project Feedback**

About mid-way through the original eleven study group sessions, I solicited formal feedback from the teachers regarding their experiences in the study group. Participants were provided with a set of questions to respond to in writing. (See Table 7.) The form indicated that their feedback should remain anonymous; however, several teachers included their name. Ten of the fourteen participating teachers submitted responses to the feedback questions; four of these ten submitted their responses anonymously.

**Table 7. Feedback Questions**

#1: What components of the study group do you find most useful and interesting? In other words, what should we continue to do, or do more of, over the next five sessions?

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#2: What components of the study group do you find least useful and interesting? In other words, what should we not continue to do, or do less of, over the next five sessions?

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#3: Are there other activities/experiences that should be incorporated into our work over the next five sessions? If so, what types of activities/experiences would be most beneficial?

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#4: What are you learning through participation in this study group? And, what would you like to learn more about?

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#5: Has participating in this study group “reached” your classroom in any way? In other words, how, if at all, has participating in this study group influenced your teaching? Your students?

### **NCTM “Homework” Assignment**

At the final study group session, the teachers decided they would like to share their work and what they had learned to a broader audience. We agreed to submit a

proposal to speak at the 2002 Annual Meeting of the National Council of Teachers of Mathematics. Upon receiving notification that our proposal had been accepted, I asked those teachers who planned on attending the conference and participating in our presentation to respond to a series of prompts as a way of beginning to brainstorm what messages and ideas we wanted to convey at the conference. Table 8 displays the four prompts used. Each of the homework assignments was collected and photocopied for future analysis.

**Table 8. NCTM Homework Assignment Prompts**

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What are some of the most important impressions about PSSM that you would like to share with a research audience?

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What did you, as a teacher, learn from the document and from the study group experience?

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What impact has the experience had on your knowledge, beliefs, classroom practice, future goals for your practice or for professional development, etc.?

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Think about what you would like to tell an audience of math education researchers and teacher educators about the document and the experience of participating in a study group. What are the 3-5 most important things you would like to have such an audience understand and know about our work and your perspective on it?

### **Interviews**

Before each school visit and observation, I confirmed with each teacher that we would have time to meet either before or after to discuss the lesson(s) observed. I also reminded teachers that I would like permission to audiotape our discussion, not only so that I would have a record of our conversation but also so that I could be free of taking written notes and thus more easily participate in the conversation. No teacher denied permission for me to audiotape our discussion. However, as I grew to know the teachers,

I was able to anticipate that a few of them would be uncomfortable with this. Thus, instead of tape recording their interviews, I did my best to capture the interview in writing, by taking notes both during and immediately after our conversation.

The interviews were designed to provide an opportunity to better understand how and what individual teachers are thinking about the document, their experience in the study group, and their beliefs and classroom practice. In addition, the interviews provided an opportunity to probe some of their responses in their journal entries and to the survey questionnaires. Interviews and written notes taken during the interview were transcribed.

### **“Big Ideas”**

During the fourth study group session, the group decided that compiling a short list of the “Big Ideas” from each standard that we read would be very useful. First, these lists would serve as summaries of our study of the document; more importantly, they could be used to discuss *Principles and Standards* with others outside our group, such as school principals, parents, and other mathematics teachers. The first few sets of “Big Ideas” were developed during study group sessions as a whole group. Teachers found this to be a worthwhile but very time-consuming process. As a result, the group eventually decided to split up the work of creating the Big Ideas across teacher-teams and even individual teachers to ensure that they would leave with a set of Big Ideas for each of the standards we had studied. These documents are important in that they provide a window into the teachers’ interpretations of the main ideas put forth in particular standards. Each document was collected and photocopied.

### **Collection of Other Documents**

All documents produced or shared during the study group sessions, as well as documents that teachers shared with me outside of the study group, were collected and photocopied. For example, during one study group discussion, Brian referred to a research article he had read regarding teaching for procedural vs. conceptual understanding. He then brought in copies of the article to the next study group session. And after Janelle and I discussed her mathematics curriculum in our journal dialogue, she brought me a copy of her district's curriculum guide.

### **Data Analysis**

The transcripts of the teachers' conversations during fourteen<sup>11</sup> of the sixteen study group sessions served as the primary data source for pursuing the research questions. As such, I begin this chapter by discussing how these transcripts were analyzed. Methods for analyzing the data collected from other sources are then presented.

### **Analyzing the Study Group Transcripts**

Analyses of the transcripts from the study group discussions were conducted in two phases. The first phase consisted of a turn-by-turn, or "micro", analysis of each teacher's individual contributions to the study group conversations, with the aim being to

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<sup>11</sup> Since teachers came to the group knowing only their partner, and since they had not necessarily begun to read the document, the first study group session consisted primarily of introductions, paperwork, and planning for the remaining sessions. During the eighth session, the group went to a computer lab on campus and explored the document's electronic examples; very little conversation around the document occurred in any substantive way. Thus, transcripts from the first and eighth study group sessions, although read and reviewed, were not included in these analyses.

mine the data for evidence of each teacher's developing ideas about and reactions to the document. A coding scheme was developed to characterize the nature and content of teachers' comments during study group sessions. In this stage of the analysis, a conversational *turn* was the unit of analysis, and the goal was to better understand how individual teachers were thinking about the document over the course of the project. Given this goal to investigate each teacher's understanding of the document, each of the fourteen transcripts were included in this analysis.

The second phase consisted of a more global or "macro" analysis of the group's discussions, in which each study group transcript was chunked into distinct conversational *episodes*, characterized by a shift in the core topic under discussion. A second coding scheme was developed in order to capture the major themes that emerged in the study group's conversations, with a focus on the cognitive demand posed by the topic under discussion and the group's treatment of that topic. In this second stage of analysis, an episode was the unit of analysis, and the goal was to describe and characterize the nature and content of the study group's discussions. Given this goal to investigate the nature of the group's conversations, and given that the group composition changed during the summer, only the first nine study group sessions (sessions #2-7 and #9-11) were included in this analysis. Each of these two major phases of analysis of the study group transcripts is described in greater detail below.

### **Phase 1: Micro-Analysis of Teachers' Turns**

The microanalysis of teachers' conversational turns was two-tiered. The first stage was ongoing throughout the project, and involved identifying and recording themes

and issues that had arisen in the study group discussions. This analysis typically occurred between study group sessions, as I reviewed videotapes from the previous session. As I read and re-read particular transcripts, I found myself zeroing in on comments individual teachers made within particular discussions and trying to understand what these comments were telling me about the teacher's developing ideas about the document and about the impact the study group was having on them. These comments served as brief, intermittent, in situ glimpses into how particular teachers were making sense of the document. Moreover, these comments sometimes emerged in the midst of rambling, off-task discussions. Without pulling them out one-by-one, I feared they would be lost in the macro-analysis of the study group's conversations.

This initial phase of identifying and naming patterns in the teachers' talk was heavily influenced by the work that Gary Martin, Mary Lindquist, and I did to develop a coding scheme and analyze feedback received in response to the NCTM's 1998 *Discussion Draft*, the first widely shared draft of what would become *Principles and Standards*. Our goal had been to find a way to characterize various constituents' (including teachers) interpretations of the draft. Given the similarities between the two projects, it made sense to build from the basic code structure that had already been developed. For example, the first few sets of codes were "base data" codes (Richards, 2000) that identified the speaker, the data source, and the location in the document to which the speaker was referring (if applicable). The next sets of codes aimed to capture the content of the turn, such as "role of technology" and "lack of support from administrators". Thus, before even meeting with the study group for the first time, I had conjectures about some possible themes that might emerge from this work. Through this

ongoing analysis, an early version of a coding scheme began to emerge that helped to classify the teachers' responses to and interpretations of the document, as well as difficult and challenging issues that arose frequently in our discussions.

The second stage of microanalysis involved a more careful and iterative sifting through the data. New patterns and themes that I had not anticipated emerged from the data and were incorporated into the coding scheme. New data were constantly compared to current codes for fit, leading to the gradual modification of codes. Transcripts from the study group sessions were imported into N5, the latest edition of NUDIST, a qualitative research software package (QSR International, 2000). This software allows for easy retrieval and comparison of current data and codes to new data and for tracking themes across study group sessions.

Two primary categories of codes were developed through this process. First, codes were developed that aimed to capture the variety of ways teachers seemed to be viewing the document and its purposes. For example, some teachers envisioned the document as a warrant or sanction for practices they had already been implementing; others saw the document as a practical resource replete with good ideas and tasks. Characterizing the ways in which teachers in this study came to view the document is important for two reasons. First, from the outset of this study, I hypothesized that the interpretations teachers would form about the document, and the understandings they might develop through reading the document and participating in the study group, would be influenced by the ways they viewed the document. Their view of the document's purposes would shape what they thought the document had to offer them, their approach to reading and studying the document, their priorities for the study group (i.e., what they

hoped to get out of the experience), and their ways of participating in the study group. For example, teachers who viewed the document as a set of mandates might approach the study group as merely an opportunity to find out what the NCTM was recommending. As such, they would be less willing to grapple with the document's recommendations, and they might view the document with skepticism or hostility. In contrast, teachers who viewed the document as a set of friendly recommendations or suggested ideas might be more willing to explore the recommendations more carefully. And teachers who viewed the document as a resource, as a set of good math tasks and classroom activities, would come to the study group with a different agenda.

A second reason for attending to the range of ways teachers viewed the document is to compare my results to those of previous work. Recall that the R3M researchers (Ferrini-Mundy & Schram, 1996) had found that the earlier *Standards* documents (NCTM 1989, 1991) were being viewed in a variety of ways. Analyzing the perspectives taken on by the teachers in this study would enable me to investigate these earlier findings with a different population, namely teachers who had participated in a serious and extended study of the latest document, *Principles and Standards*. Would this group of teachers come to develop similar perspectives? Would new perspectives emerge?

The second category of codes aimed to capture the key ideas from the document that teachers were taking up and grappling with in their discussions. For example, a salient issue for many teachers became the importance of a coherent, connected mathematics curriculum that is well-communicated among teachers from grades K through twelve.



## **Phase 2: Macro-Analysis of Teachers' Conversations**

Creating meeting maps. Recall that one goal of this research was to characterize the nature and content of teachers' discussions of the document. As I discussed in Chapters 1 and 2, little research to date has investigated how teachers might make sense of and react to an instructional policy document when given sustained opportunities to do so in a serious way. Would teachers be capable of such work, and if so, what would their conversations "sound like"? Which ideas would they attend to and pursue, and which would they bypass? To pursue these questions, I needed to find a way to describe and characterize the conversations that took place during the study group sessions. In surveying the massive amount of data available from just the study group discussions – 55 hours of study group discussions, captured in sixteen transcripts, ranging from 38 to 92 single-spaced pages in length – it quickly became clear that I would first need to find a way to organize or "chunk" the transcript data to make it more manageable.<sup>12</sup> As a first step, I went about creating a *meeting map* for each of the study group session transcripts. The meeting maps were designed to serve as brief summaries that captured particular features of the sessions, such as who were the discussion leaders for the session, which parts of the document were under discussion for that day, what were the big ideas taken up during the discussion, and what types of activities the group engaged in during the session. Table 9 displays the meeting map for the third study group session.

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<sup>12</sup> This organization process is actually the beginning of analysis. In other words, even at this preliminary stage, I was beginning to make decisions about which data to attend to and which to ignore, and about how to name or categorize the data I deemed useful in pursuing my research questions.

**Table 9. Meeting Map for the Third Study Group Session**

Date & Length	March 5, 2001; 3 hours
Leaders	Callie and Mimi
Document	Algebra Standard (Chapters 3 & 6)
Central Themes	<p><u>Discussion of the Algebra Standard</u></p> <ol style="list-style-type: none"> <li>1. Anyone tried problems like the telephone plan problems? (Callie) (2-3)</li> <li>2. How to pull out the algebra from the telephone problems (Kayla) (3)</li> <li>3. Return to telephone plan problems: Graphs/other reps/technology, student difficulties (Callie) (p.3-5)</li> <li>4. Use of computer programs to teach algebra (Callie) (5)</li> <li>5. Feasibility of using technology (e-examples, Illuminations site) (Dawn) (5-6)</li> <li>6. Where to buy cheap graphing calculators (Brian) (p.6-7)</li> <li>7. What is "algebra" for middle school? (Mimi) (p.7-11)</li> <li>8. Linear equations – Exploration vs. symbol manipulation (Brian) (p.11-12)</li> <li>9. Do students naturally seek out formulas? (Callie) (12-13)</li> <li>10. Appropriateness of non-linear functions in middle school (Kayla) (p.13-14)</li> <li>11. Different meanings of "variable" (Brian) (14-15)</li> <li>12. Document as tool for teacher learning, as advocate for pd (Janelle) (p.15-16)</li> <li>13. Develop conceptual understanding before symbol manipulation (Dawn) (p.17)</li> <li>14. Developing mathematical ideas over time requires a connected, coherent curriculum (Edgar) (p.17-19)</li> <li>15. PSSM as tool for teacher learning (Janelle) (p.19-20)</li> <li>16. Integrating algebra with geometry (Brian) (p.21-22)</li> <li>17. Knowledge for teaching is more than math content knowledge (Dawn) (22-26)</li> </ol> <p><u>Algebra Task</u></p> <ol style="list-style-type: none"> <li>18. Discussing the algebra task (Dawn) (26-28)</li> <li>19. Dara's example: What counts as a proof? (Dawn, Kayla) (28-30)</li> <li>20. Discussing different proofs; possible student misconceptions (Dawn) (30-33)</li> <li>21. What is proof, and what does proof mean for middle school? (Kayla) (34-35)</li> <li>22. Sharing lesson study proposals (35 – 48)</li> </ol>
Math Task	Algebra Task – Algebraic proof of the Pythagorean theorem
Lesson Study	Yes
Other Activity	None
Notes	Discussion of Algebra Standard is jumpy, fits and starts; First time group works on a math task together

The most important feature of the meeting maps became the *central themes*, as they came to encapsulate the key ideas that the teachers took up in the study group discussions. To identify the central themes, I began by reading a clean version of the entire transcript through from beginning to end, stopping to make occasional notes about what ideas the teachers seemed to be grappling with in their conversations or when there seemed to be clear shifts in the conversation from one topic to another. I then made a second, more careful pass through the transcript, working more diligently to name or briefly describe the issues under discussion within each passage. An important part of this work was identifying where discussion of one issue ended and the next was introduced. This work also involved identifying the study group member who initiated each new central theme. Doing so would allow me to investigate individual teachers' tendencies to introduce new discussion topics and if certain teachers tended to introduce particular types of topics. Asking myself questions such as, "What is this teacher really trying to say here?", "What are the teachers really talking about in this passage?", and "Is this a new idea that is being introduced by teacher X?" proved useful in naming the central topic under discussion and distinguishing shifts in topic. After a third and sometimes fourth careful perusal of the transcript, an initial list of the central ideas taken up by teachers during the study group session emerged.

Identifying the central themes discussed for each study group session proved more difficult and time-consuming than I first anticipated. Upon the first few passes through the transcripts, the teachers' conversations often came across as rambling streams of seemingly unrelated topics, in which teachers rarely built on each other's ideas or took up a topic and grappled with it at length. Identifying when one topic under discussion

ended and the next began, and pinpointing exactly what main idea was being discussed were both challenging. As a result, early summaries of central themes culminated in quite lengthy and fine-grained lists of discrete topics. I found these initial impressions, and the resulting summaries, unsettling for two reasons. First, they did not fit with the sense I had had of the conversations as they had occurred. That is, when I had been sitting in on and participating in the discussions in real time, the conversations had felt more connected and coherent; rarely had I been unable to follow the logic from one teacher's comment to the next. Second, they did not fit with my assumptions about how people process new experiences and learn. Rather than representing the teachers' discussions as concerted attempts to make sense of not only the document but also of each other's comments about the document, the initial summaries seemed to portray the teachers' discussions as incoherent and disconnected. This sense that I wasn't quite "getting it right" led me to make additional passes through each of the transcripts, working from first drafts of the meeting maps. As I did so, I attempted to view and interpret the discussions through the lens of teachers-as-sense-makers. In other words, I explicitly worked from the assumption that, for the most part, teachers were actively trying to build on or link their comments in some way to comments made previously by others. Repeatedly asking myself questions like, "How does this teacher's comment connect to what was just said?" and "Do these brief discussions of seemingly distinct topics really fit under one big idea?" helped me to take on this perspective. Gradually, I began to see the study group conversations in a different way. What at first appeared to be a string of short-lived discussions of loosely related topics reemerged as a sustained attempt by the group to tackle a larger issue from different angles or different perspectives. And, what at first

seemed to be abrupt and frequent shifts in the topic at hand became attempts to flesh out one or more issues related to the topic, or to present a personal experience that would illuminate or exemplify the topic at hand. As a result, topics from the early summaries were often collapsed and renamed, and what were once lengthy lists of up to 50 different discussion topics for each study group session became more consolidated lists of the “big ideas” taken up during the study group discussions.

Before discussing the next step in the macro-analysis of the study group transcripts, two caveats are in order. First, adopting the teachers-as-sense-makers lens more explicitly did not mean that every teacher’s comment was eventually interpreted as completely “on task”, sensible, and successfully contributing to the conversation at hand. Frequently, teachers made comments that did not seem to connect to the central theme being discussed. In some of these cases, the teacher succeeded, whether purposefully or not, in abruptly and, in my opinion, prematurely shifting the conversation to a completely different topic. Second, pushing myself to see the logic or connectedness in the teachers’ talk did not mean that every conversation was deemed to be coherent and well developed. Rather, I frequently encountered conversations in which a string of loosely coupled topics were introduced, commented on briefly (or not at all), and then quickly dismissed. In many of these cases, I was unable to identify an overarching theme under which these fits and starts might all fall. In these cases, the discrete, unelaborated topics were not collapsed but each became their own “central theme”, and are often identifiable by their short page span in the meeting maps.

From this point on, I will use the term *episode* to refer to the teachers’ discussion around a particular central theme at a particular time during a particular study group

session. A new episode is signaled by the attempt – successful or not – to introduce a new topic under discussion. Thus, each episode is associated with exactly one central theme, but a central theme may be taken up in several episodes within a study group session or across sessions.

Central themes vs. codes. Often, a code that had emerged from the microanalysis of individual teachers' talk re-emerged as central themes in the study group's conversations, and vice versa. However, not all codes became central themes, and not all central themes became codes. This is reasonable, for they differ fundamentally in terms of the unit of analysis under investigation. Central themes that emerged through the macro-analysis were ways of characterizing the entirety of a conversational episode. They aimed to answer the question, "What is the big idea that teachers are collectively grappling with in this episode?" In contrast, the codes that emerged through the microanalysis were ways of characterizing individual conversational turns. They aimed to answer the question, "What is the big idea that this particular teacher is introducing or pursuing in this particular turn?"

Characterizing the episodes. An important contribution of the meeting maps was that the identification of central themes provided me with a visual record of the scope and sequence of the teachers' discussions during each study group session. In other words, this was a first step in being able to answer the question, "When given the opportunity to study a document like *Principles and Standards*, what ideas do teachers take note of and try to make sense of?" The next step was to more carefully study the teachers' conversations around these central themes. I began by pursuing something that had struck me as I studied the transcripts repeatedly in creating the meeting maps, namely that the

episodes seemed to vary not only in central theme, but also in quality or substance.

Certain discussions seemed more valuable than others in terms of their potential to be educative for the group members. As I pursued this notion further, I began to notice that the episodes seemed to fall into one of three types. In some conversations, teachers posed and then grappled with a substantive question or problem. In these conversations, teachers would flesh out some of the issues surrounding the problem, take a stand on one or more of the issues, and/or suggest possible solutions. These conversations seemed most “successful” to me – teachers began with a substantive topic and then grappled with it in productive ways. One might characterize these episodes as “realized potential” – the teachers had taken up a significant issue and, through their discussions, seemed to make some progress in, if not resolving the issue, considering the issue from new or different perspectives or considering possible solutions. The passage below provides a clip from an episode of this type.

Brian: So, how much is proof dependent upon communication? And, is proof indeed not just communication? Because as I was reading this [the Reasoning and Proof Standard], I was thinking what we say about proof could also be about the Communication Standard.

Carla: And when they talk about constructed response questions, is that a proof?

Lara: Or is that problem solving?

Dawn: I was just thinking as Carla was asking, “Well, I think this is proof...” I was wondering if we needed to try and come up with a definition of proof because...

Tim: No, we only have an hour and a half!

Dawn: Yeah, so Brian, you’re asking if proof is more than communication or if they’re the same?

Brian: Well, my first response in looking at this, I was thinking it was

going to be sort of like focused on the formal concept of proof, but it seems to be much more or less than that. It depends – if I’m a high school teacher who wants rigorous proof, then I’d say that this document is weak and fluffy because it doesn’t talk about real proof, it talks about communicating. My personal preference, I tend, I think this way. Proof is all about explaining their answer, or, you know, looking for patterns and that kind of thing, but the community we serve, you know, what they see perceive sometimes is different than what we see in our classroom.

Edgar: Maybe communication is a vehicle for proof. I mean we’ve, through our history we’ve taught things; we’ve imparted knowledge in many different ways. I mean the formal proofs were a way that mathematicians could pass on the things that they had learned, that they should demonstrate that they were accurate and they were right or fundamentally sound. What Andrew Wiles, just within the last decade, proved Fermat’s last theorem, finally. I mean it was a rigorous proof and it was written, and it was several hundred pages, but it was written in that format so that other mathematicians could take it and could sift through it, could rip it apart and make sure that there weren’t things that he’d overlooked. The formal proof is a way to be rigorous and make sure that you’re covering everything that needs to be covered and a way to pass that on to other people. In a less formal way, communication is a means of doing the same thing. More formal or more informal, if a student is being methodical and making sure that they have covered all their bases and understand the problem and are passing that onto somebody else. The one is necessary; the second is, maybe circumstantial. They need to understand it themselves. And then, if that’s enough, because they’re studying for a test or they’re finishing a homework assignment, then they stop there. If they are explaining it to somebody else, then communication is a vehicle.

Carla: If we’re going to have a proof and one is formal, very formal, and one is less formal, which one will we get farther with? I mean I guess if you looked at all the different ways they did the area of a trapezoid, what works for one, the very formal, might not make sense to me. I guess I like the joy of having multiples so that one sticks with me. You know and maybe... Because I always thought that a lot of students dropped out of geometry simply because of proofs and things like that, that maybe if things weren’t as formal they would have stuck with the subject longer. I know like in our district, we don’t have, it used to be traditionally Algebra I, then Geometry, then Algebra II. And ours has Geometry and Algebra II switched around, because they thought they lost a lot of students in Geometry, and so they were hoping they would keep them in another year, which is one of the reasons why... And are the proofs, you know on page 59 where it says, “Students need to encounter and build proficiency in these forms with increasing sophistication as they move through the curriculum.” If you’re going to give them a problem and one can make it



more sophisticated, doesn't that allow for the ability differences a little bit more, too? (Tenth Study Group Session)

In this episode, teachers grapple with notions of proof, exploring the relationship between proof and communication in mathematics, and comparing and contrasting formal and informal proofs.

In contrast, in other conversations teachers would begin with a provocative question or issue, but then would quickly digress into a conversation that seemed less fruitful. Teachers might commiserate about the problem, or share specific cases of the problem from their own experience, but they would tend to treat the problem superficially, or one-dimensionally. In other words, teachers would fail to take up the issue in any substantive way. For example, consider the following clip from an episode from the second study group session.

Mindy: And along with that, actually, where does the whole integration of math fit? I don't know if at your school you're pushed to integrate your other subject areas, but at our school we have a big push to integrate with social studies and math and that sometimes leads you [away] from the curriculum. So, I don't know what you guys think...

Edgar: And, sometimes it can be powerful, but sometimes it can be awfully stretched.

Mindy: Oh yeah.

Edgar: How can we cram mathematics into this English lesson?

Kayla: Statistics...

Edgar: We're integrating! By God, we're integrating!

Lara: When I interned they called that "frog math". We're doing frogs in biology, so we'll count frogs in math!

<Laughter>

Kayla: Graph them...

Lara: But that's kind of like the extreme of that...

Brian: Well, we probably should move ahead... (Second Study Group Session)

In this episode, Mindy poses a challenging question regarding what role the integration of math with other disciplines should play. Although other teachers seem to recognize and appreciate this dilemma, they fail to address Mindy's inquiry in any substantive way. I began to think of these episodes as "missed opportunities" – the teachers had initiated a topic that seemed to have potential, but did not succeed in grappling with that topic in productive ways.

Finally, some conversations were at a disadvantage from the beginning, in that teachers began with a topic that had little potential for catalyzing rich discussions. For example, at one point during the third study group session, Brian shifted the group's conversation from a discussion of using technology in mathematics instruction to a conversation about where teachers could purchase inexpensive graphing calculators.

Brian: So, what I think you're talking is you would like to have something that your whole class could do at the same time... it's a difficult situation...

Callie: Yeah. I would like to expand more, but I just, I guess that's where I... I'm not sure, and so I don't and I am curious whether others do [use technology].

*~ New episode begins ~*

Brian: Well, I found a great place you can buy graphing calculators cheap.

Callie: Really?

Brian: S & K? Or, whatever it is?

Carla: D&H

*Laughter*

Brian: D& H. You can buy re-built TI 82's for like forty bucks.

Someone: Whoa!

Carla: I mean it may be, I know D & H, the advantage to that is... The D & H has ones that are, you normally get a one-year warranty, and then they extend it for two more years. So, these calculators are good for three years, which I think is amazing.

Brian: Well, and the re-built ones are, all it is, is that they sent them through inspection and they've failed. They've sent them back, re-built them, and sent them to inspection again and they passed... for forty bucks a piece. (Third Study Group Session)

In this episode, Brian introduces a topic that offered little potential for the group to engage in discussion in a serious way. Rather, the conversation that follows is one in which teachers simply share information and practical advice. Although the teachers seemed to appreciate and value conversations like these, I would argue that these types of discussions were not the wisest use of the study group, for they did not call upon the diverse expertise, experience, and perspectives that the teachers brought to the group. Rather, conversations like these primarily involved one teacher telling the group a piece of information and the others listening and occasionally asking clarification questions, something which could have just as easily been accomplished over the listserv, or during one of the breaks. Thus, I began to think of these kinds of episodes as “without promise”, for they seemed to have little potential from the beginning to offer teachers opportunities to learn anything beyond the specific piece of information being shared.

These distinctions I was noticing in the teachers' conversations seemed similar to the way researchers from the QUASAR project<sup>13</sup> had come to characterize mathematics

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<sup>13</sup> QUASAR (Quantitative Understanding: Amplifying Student Achievement and Reasoning) was a project designed to provide mathematics instruction that focused on students reasoning, problem solving, and

instructional tasks (Stein, Smith, Henningsen, & Silver, 2000). Stein et al. (2000) argue that the mathematical tasks students are asked to work on – more specifically the type of thinking these tasks require – are a key determinant of what mathematics they learn. They coined the term *cognitive demand* of a mathematics task to refer to “the kind and level of thinking required of students in order to successfully engage with and solve the task” (p. 11) and distinguish between tasks that pose low-level cognitive demands and those that pose high-level cognitive demands.

Opportunities for student learning are not created simply by putting students into groups, by placing manipulatives in front of them, or by handing them a calculator. Rather, it is the level and kind of thinking in which students engage that determines what they will learn. Tasks that require students to perform a memorized procedure in a routine manner lead to one type of opportunity for student thinking; tasks that demand engagement with concepts and that stimulate students to make purposeful connections to meaning or relevant mathematical ideas lead to a different set of opportunities for student thinking. (p. 11)

Low-level demand mathematics tasks are characterized by their focus on obtaining the right answer, their application of previously learned procedures or facts, and their lack of ambiguity in terms of what is expected of students; they require little cognitive effort on the part of students. In contrast, high-level demand mathematics tasks are complex, ambiguous (i.e., they do not directly suggest a solution method), and require students to draw connections between different concepts and processes; they require a great deal of cognitive effort on the part of students. Stein et al. argue that in order to develop students’ abilities to reason, problem solve, and communicate in mathematics, they need to have many opportunities to grapple with high-level demand tasks.

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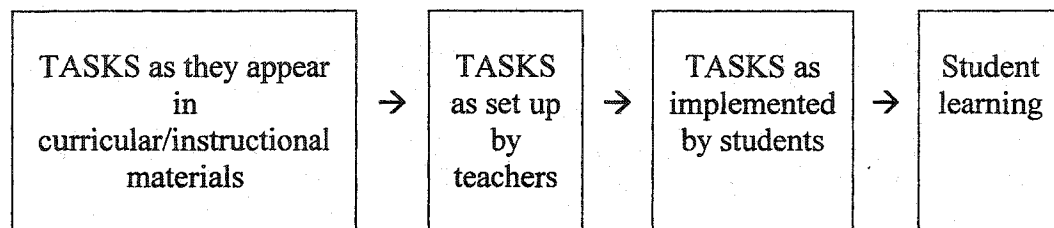
communicating about mathematical ideas to middle grades students in economically disadvantaged schools.

In their research on mathematics instruction in middle grades classrooms, Stein et al. (2000) found that considering the level of cognitive demand inherent in a mathematics task is not sufficient. The researchers noted that during interactions around a high-level demand task, teachers and students often managed to reduce its cognitive demand. For example, students often succeeded in reducing the complexity of a high-level demand task by browbeating the teacher into telling them which procedure they should apply. Teachers, under time constraints to complete one task and move on to the next topic, would sometimes step in and oversimplify the task, thereby removing the cognitive challenge for students. In fact, Stein, Henningsen, & Grover (1999) report that of all the high-level demand tasks implemented by teachers during their study, only about one-third of the tasks were maintained at a high level as students engaged with them. Thus, in trying to ascertain the potential of a task for student learning, it is important to consider not just the cognitive demand inherent in the task itself, but also the way the demand of that task is maintained or reduced by both the teacher and the students when it is implemented in the classroom.

The work of Stein and her colleagues culminated in the development of a framework for how mathematics instructional tasks play out in classrooms. (See Figure 2.) Stein et al. report two major findings from their research: “(1) mathematical tasks with high-level cognitive demands were the most difficult to implement well, frequently being transformed into less-demanding tasks during instruction; and (2) student learning gains were greatest in classrooms in which instructional tasks consistently encouraged high-level student thinking and reasoning and least in classrooms in which instructional tasks were consistently procedural in nature” (p. 4). Thus, high-level cognitive demand tasks

offer the greatest opportunity for student learning, but present the greatest challenge in terms of maintaining the level of cognitive demand during implementation.

**Figure 2. The Mathematical Tasks Framework**



As I studied my own data more carefully, this notion of the cognitive demand of a task seemed increasingly applicable to the types of episodes I was finding in the study group transcripts. I began to distinguish between a central theme that teachers took up within an episode, and their treatment, or discussion, of that central theme. With this distinction in mind, I started to conceptualize the central themes as a form of instructional task within a study group discussion, and the teachers' discussions of the central themes as their implementation of those tasks (central themes) in the classroom (study group session). This enabled me to draw several analogies. First, Stein et al. (2000) argue that mathematics instructional tasks encompass the basis of students' opportunities to learn mathematics in classrooms. In my work, I saw the discussions of the central themes in the study group sessions as the key opportunities for teachers to learn about and from the document in this professional development project. In other words, in a study group session (classroom), the initiation and pursuit of various central themes, through conversation, were the central tasks in which teachers were engaged, and were the

primary vehicle for their learning about the document. Second, just as different types of mathematics tasks can require different levels and kinds of student thinking, I was beginning to see that different conversations around the document were requiring different levels and kinds of thinking from the teachers in my study group. Third, just as Stein et al. identified low-level demand tasks as those that are unambiguous and relatively straightforward for students to solve, I was finding similar traits in some of the central themes initiated by teachers – topics that were unambiguous and relatively straightforward to respond to. Fourth, just as high-level demand tasks were characterized as those that suggest no straightforward solution process and require students to make connections between different mathematical ideas, some of the central themes taken up by teachers were multi-faceted and complex, suggested no easy resolution, and called on teachers to make connections between different ideas. Finally, just as Stein et al. found that teachers and students could reduce the initial cognitive demand of an instructional task, transforming it from a high-level to a low-level cognitive demand, I was finding that my teachers could reduce or avoid the complexity of a central theme, transforming what could have been a “successful” conversation to a “missed opportunity”.

Given these parallels, I decided to try to apply this notion of cognitive demand to what I was finding in the teachers’ study group discussions. Working from Stein et al.’s definition of the cognitive demand of a task as “the kind and level of thinking required of students in order to successfully engage with and solve the task” (p. 11), I developed the following definition:

*The cognitive demand of a central theme is the kind and level of thinking required of teachers in order to successfully engage with and (attempt to) resolve the issue under discussion.*

I then set about developing a coding scheme for the episodes, with the primary goal being to characterize the episodes in terms of the cognitive demand they presented to teachers. First, recall that each episode was already identified by exactly one central theme, and by the study group member who had initiated that central theme. Next, I set about coding for the level of cognitive demand – high or low – posed by the theme under discussion. Table 10 provides the five criteria used to determine if a central theme presented a high-level or low-level of cognitive demand for the teachers. Determining the level of cognitive demand of a particular central theme involved assessing the theme's *potential* along each of these five dimensions. In considering a particular central theme, I would ask myself questions such as, "Does this central theme represent a 'big idea' or overarching issue in mathematics education?", "Are there multiple ways of looking at this issue?", and "Could discussion of this central theme allow for teachers to offer opposing views?"

Making these distinctions turned out to be fairly straightforward because they involved only judging the central theme's potential to stimulate serious discussion of a complex issue. For example, consider the passage below from a discussion initiated by Edgar during the second study group session.

Edgar: Speaking of all the stuff that's crammed in here, I don't mean to jump ahead of your brilliantly executed timetable but this is coming from the Curriculum Principle which is a little ahead of where we are, and I'm sorry but since you're talking about that...

Brian: <Inaudible>

Edgar: This was something that I put between my two journal entries that I sent to Dawn. It was just a random question. The book says that we should be teaching "important mathematics".

Monique: I'm sorry, what did you say?



Edgar: The book, the document says that we should be teaching “important mathematics”. And one of the questions that that begs is then what does *Principles and Standards* deem to be unimportant mathematics? What exactly is that? It seems like there’s so much that we’re trying to do, and right now lots of it becomes not as important because it’s fragmented and splintered and you do a little bit here and a little bit there, just thrown all over the place. It seems like nearly anything could be considered important, if it’s within the right framework, if it’s within the right problem or in the right context. And so, I’d just be curious as to what exactly would be deemed unimportant mathematics? (Second Study Group Session)

In this episode, Edgar poses a provocative question to the group: What would the document posit as unimportant mathematics? Tackling this question is non-trivial. The document does not clearly specify what mathematics need *not* be taught; its stance would need to be carefully inferred from a compilation of statements about what mathematics is most important for students to learn. However, simply grappling with this issue would provide an opportunity for teachers to develop a better understanding of the document’s recommendations. In addition, through discussion, individual teachers might become more aware of and clearer about their own stance and beliefs about school mathematics. Thus, this central theme was coded as posing a high-level of cognitive demand, or HCD, because of its potential to stimulate teachers’ learning.

Another example is provided in the passage below, in which Brian introduces a new central theme, namely the constraints faced by teachers trying to take additional coursework at the local university.

Brian: I also wanted to talk about another thing here, is a sort of curriculum thing. I know now that Michigan State is on the semester system. They want us to be better teachers, to go back and take classes, but to try to get a class that you can get into is almost impossible. I mean, it’s only offered during the day; you’d have to take off six weeks of teaching to go take this class.

Lara: Michigan State is not a user-friendly college for...

Brian: But, I mean, yet they're the, I know that their department is one of the first ones to scream about we need to do more for teachers. And we need to have better math education and blah, blah, blah, blah, blah. Yet, they don't provide opportunities for teachers to take advantage of the resources that they do offer and realize that we can't take the time off from teaching. They have to offer them during the summer, when school is over, not the summer that starts in the beginning of May. It's not an option for us. Or evening classes, or something, that we can take those classes that they require or want us to take or need to take. So, something has to give. It's not just Michigan State. (Fourth Study Group Session)

**Table 10. Characteristics of Central Themes at Each Level of Cognitive Demand**

High-Level Demand Themes	Low-Level Demand Themes
Centers around an overarching, substantive issue (i.e., equity, role of technology in mathematics instruction)	Centers around practical issues (i.e., how to use computers in geometry instruction) and/or factual information
Is problematic; no immediate solution or resolution is available	Is not problematic; an immediate solution or resolution is available
Is multi-faceted, nuanced	Is one-dimensional, few if any nuances
Can involve risk-taking on the part of the participants	Little to no risk involved on the part of the participants
Easily debatable, easily allows for differing points of view	Not easily debatable, does not easily allow for differing points of view

The central theme initiated by Brian in this passage focuses on a practical problem – difficulty gaining access to courses at the local university. This turned out to be an issue familiar to several teachers in the group, and they spent a good period of time sharing their experiences. However, the topic itself did not have much potential to stimulate a discussion in which teachers would grapple with a substantive issue. In other words, this topic afforded few opportunities for teachers to learn from the discussion, beyond additional information about the constraints posed by trying to take additional coursework at the university. Thus, this central theme was coded as low-level cognitive demand, or LCD.

After coding the episodes for the level of cognitive demand inherent in the central theme, each episode was then coded for the level of cognitive demand achieved and maintained during the teachers' discussion of the central theme. Table 11 displays the five criteria used to determine if the teachers' discussion (or, "implementation") of a particular central theme was carried out at a high-level or low-level of cognitive demand. Determining the level of cognitive demand of a particular discussion of a central theme involved assessing the *realized potential* of the teachers' discussion along each of these five dimensions. In considering a particular episode, I would ask myself questions such as, "Did the teachers take on a 'big idea' or overarching issue in mathematics education?", "Did the teachers consider multiple perspectives?", and "Did discussion of this central theme result in teachers offering opposing views?"

Making these distinctions turned out to be less straightforward than the coding of the central themes. Often, the episodes would consist of a series of mini-discussions in which the level of cognitive demand would shift back and forth dramatically between high and low. Consequently, I introduced a new level of cognitive demand, "mixed", to represent discussions like these.

One issue I confronted in this stage of analysis was how to treat the occasional one-turn episodes – episodes in which one teacher attempts to introduce a new central theme, but the idea is not taken up by the other participants. For example, in the passage below from the second study group session, Brian tries to initiate a discussion of the following statement made in Chapter 1 of the document: "Although there will never be complete consensus within the mathematics education profession or among the general public about the ideas advanced in any standards document, the Standards provide a

guide for focused, sustained efforts to improve students' school mathematics education" (NCTM, 2000, p.6). For whatever reason, the next speaker, Monique, does not follow up on Brian's comment but shifts the conversation to a discussion of when students are ready for algebra and what the word "algebra" means.

**Table 11. Characteristics of Episodes at Each Level of Cognitive Demand**

High-Level Demand Episodes	Low-Level Demand Episodes
Involves grappling with and/or trying to develop a better understanding of the central theme	Involves sharing or seeking practical advice or factual information
Involves problematizing the issue; possible resolutions are sought but not realized	Does not involve problematizing the issue; Might involve oversimplifying the issue; Resolution or solution is determined
Involves consideration of multiple perspectives and fleshing out nuances	Focuses on only one dimension of the issue
Involves one or more participants taking a risk	Does not involve participant taking a risk
Involves debate or disagreement	Not easily debatable, does not easily allow for differing points of view

Brian: That was interesting to me. Also, on page six, the second paragraph, "Although there will never be complete consensus..." I love that. There has been an awful lot of controversy, not just in our school district, but within our school about what should be taught and what shouldn't be taught. And I think years of fighting about it has given us a new strength and conviction. I don't know if the rest of you had the same reaction to it. [Inviting others to comment]

Monique: We've all been taught by and large that, "students just aren't developmentally ready for that yet. I don't know why you're trying to teach them something they aren't developmentally ready for." But yet in this book, you know, my 18-month-old daughter should be able to at least put things in patterns, which are the beginning steps of algebra. And I know she can do it; I watch her do it. I know she can put her blocks red, blue, red, blue, red, blue. So, if they [the Writers] are calling this algebra and my 18-month-old daughter can do it, it just baffles me that [some people will say] "sixth and seventh graders just aren't developmentally

ready.” Yeah, they are! We just need to start them earlier and call it what it is. (Second Study Group Session)

On the one hand, one could argue for discarding one-turn episodes like this one. The fact that other teachers did not elaborate on Brian’s comment could mean that the remaining teachers did not find this an important or interesting issue in the document. By consisting of only one turn, these episodes obviously shed little light on how teachers were thinking about the notion posed by Brian that complete consensus will never be attained. On the other hand, episodes like the one above do reveal ideas that the document catalyzed a teacher to introduce as a potential discussion topic. Perhaps other teachers were struck by the passage Brian quoted, but Monique jumped in with a new idea before they had a chance to respond. In the end, I decided that one-turn episodes suggested themes that the document had the potential to stimulate teachers to take up and react to, and so I included them in the cognitive demand analyses. As the teachers’ discussion of the central theme was not available for coding, these episodes received a code of “N/A” (not applicable) for the discussion of the theme.

Analyzing the episodes in terms of their cognitive demand would provide one characterization of not only the nature but also the quality of the teachers’ discussions of the document in the study group sessions. For example, if higher-level “tasks” (central themes) have more potential to be educative for teachers, then determining the proportion of higher-level demand tasks that the document catalyzed these teachers to discuss is one measure of the educative potential of the document. Moreover, identifying and describing the high-level central themes for which teachers maintained the demand level during their discussion, and even those central themes for which they did not, would shed light on the

substantive issues and ideas the document has the potential to stimulate teachers to take up. Of course, it is impossible to conclude with absolute certainty that their reading of the document catalyzed teachers to initiate each of the high-demand central themes. That is, it is possible that teachers would have brought up some of the high-demand central themes on their own, regardless of the document's influence.

In order to tease out those episodes that were more likely to have been catalyzed by the teachers' reading of the document from those that were not, I developed a new coding category, *role of the document*. Analyzing the episodes for their relationship to the document revealed that the document could assume three possible roles within an episode – *document as catalyst*, *document as referent*, or *no role*. Those episodes in which a teacher initiated a new central theme by directly quoting or paraphrasing a passage from the document were coded as *document as catalyst*. The passage below, in which Lara initiates a new discussion, provides an example of such a case.

Lara: I liked this – this kind of applies to science, too, which I teach. It says, it's also in the Teaching [Principle], it says, up at that top part about the professional development. It says, "... [teachers must also decide] how to support students without taking over the process of thinking for them and thus eliminating the challenge" [p. 19]. Sometimes they, sometimes they just so much want the shortcut and will just give me the answer because that's what they're so used to. That really, that struck a chord with me.

Monique: [Joyce] and I were just talking about that on our way here. That some of our students were working on the, 2 halves x plus one third equals, you know. And they'll be like, "Okay, do I add or subtract? Which one do I flip? Do I have to make it...? And they don't even care. I mean, it's not even like they really understand the process. They just want to know the steps and they just want to do it. They don't *want* to understand it. [Joyce] was saying that she tried to go through and like estimate and she thought that they got it. But my honors kids were just like, "We don't even care. Just tell us what to do so we can do it."

Dawn: Where does that come from?

Tim: Parents

Brian: Previous experience

Someone: Experience in schools

Joyce: Well, I think that's how we've taught it. One of the things that I read that really [struck me] today, because we've been trying to work on these equations forever. And, still, the kids, like I was saying, twenty days in a row this same kid comes up to me and asks me the same question. Do I add or subtract, and which ones do I flip? And I'm like, ugh! So, today we just started out and we just wrote the equation. And we just started trying to analyze it. You know, what are we really looking here for? What is this  $x$ ? What is it that we're supposed to be finding? And we just kind of went through it step by step. And then we just started making estimates. I said, "Let's, you know, would this work if  $x$  was equal to one? We'll just try whole numbers. What would this side of the equation be equal to if we put 1 in for  $x$ ?" And they said, "Well, around 5." And I said, well, okay. What if  $x$  was 2? Well, then it would be around 8. ... But, maybe if we at least try to take the time to do that... Because quite honestly, for myself, I think I've been just teaching the algorithm. You know, how to do it, because I learned it that way. It was okay for me. But for them, I don't really think it is. And, as I read this, it just really made me stop and think that, you know, that that's something I don't think that I've done right. Maybe I need to start going slower with this and trying to get them just to the concept of it and then the algorithm will follow. (Fourth Study Group Session)

In this clip, Lara initiates a new discussion by directly quoting a passage from the document that she found meaningful. Other teachers then took up the issue raised in this passage – how teachers can support students without doing all of the work for them. Joyce takes a risk by admitting some responsibility for her students' predilection to be told how to solve problems rather than to think on their own. She also refers back to the document, explaining how the passage quoted by Lara made her reconsider her own classroom practice. Episodes like this one, in which the central theme is clearly drawn from a passage in the document, are particularly noteworthy in that they indicate the

document's potential to stimulate discussions amongst, and serve as a learning tool for, teachers.

In other episodes, teachers would introduce a central theme without making any direct reference to the document. However, as the discussion around the central theme evolved, one or more teachers would often refer back to the document, to provide clarification for what they were trying to communicate or to bolster their argument. These episodes were coded as *document as referent*. Episodes in which teachers made no direct reference to the document whatsoever, either in introducing the central theme or in elaborating on it were coded as *no role*.

Considering both the level of cognitive demand inherent in the central theme itself, and the level of demand that is actually achieved and maintained by teachers as they discuss the central theme, allows for five possible discussion scenarios, as depicted in Table 12. In Scenarios 1, 2, and 3, a high-level central theme is introduced for discussion. In Scenario 1, the level of cognitive demand is maintained during discussion of the theme; in Scenario 2, the level of cognitive demand fluctuates during the conversation; and in Scenario 3, the level of cognitive demand declines as teachers engage in discussion. In Scenario 4, a low-level central theme is posed for teachers to consider, and teachers maintain this low level of cognitive demand during the discussion. In theory, teachers could then raise the cognitive demand of a low-level task through their discussion, allowing for two additional cases (Low-Mixed and Low-High). However, Stein et al. (2000) report that, "low-level tasks virtually never result in high-level engagement" (p. 14). I anticipated similar patterns for my "tasks". It would be challenging enough to sustain conversation of a high-level task at a high level, let alone



catalyze high-level discussion of a low-level task. Finally, Scenario 5 represents the one-turn episodes.

**Table 12. Five Possible Discussion Scenarios**

	Cognitive Demand of the Central Theme ("Task")	Cognitive Demand during Discussion of the Central Theme ("Task Implementation")	Composite Score
Scenario 1	High	High	H-H
Scenario 2	High	Mixed	H-M
Scenario 3	High	Low	H-L
Scenario 4	Low	Low	L-L
Scenario 5	High or Low	N/A	N/A

I conclude this chapter by describing analysis of data from sources other than the study group discussions.

### **Analysis of Other Data Sources**

Teachers' applications to the project, dialogue journal entries and responses, mid-project feedback, NCTM homework assignments, Big Ideas, and interview transcripts were imported into the N5 database and analyzed using the coding scheme I developed from the micro-analysis of the study group transcripts. Field notes from classroom observations were typed into Word documents (one for each teacher) and imported into the database. These data received base codes only.

Due to the sheer number of communications on the listserv, I began analysis of the listserv discussions by first categorizing each message into one of two types. Messages in which participants initiated or continued a conversation about issues around mathematics or mathematics teaching and learning were coded as *substantive* (S). Messages in which participants shared resources or planned for upcoming study group sessions were coded as *practical* (P). This analysis revealed that teachers only sporadically used the listserv as a forum for continued conversations of important issues; they primarily used the listserv for practical purposes such as sharing resources and planning. Reflection on and analysis of our discussions about the listserv reveal several potential reasons for this. First, I was surprised to learn that many of the teachers had never participated on a listserv of any kind; moreover, several of them were not very familiar or comfortable with email technology. Consequently, the listserv was an intimidating medium to some. For example, Janelle made the following comments during a whole-group discussion of possible uses of the listserv:

Janelle: I'm still learning how to, I think I'm more of a paper and pencil type person. So, I'm still learning to use email and this sort of thing. So, I tend, as I sat in front of it, I have to be honest... it was sort of like the headlights, the doe in the headlights. Gee, I really don't know what to say to you guys. So, I'm still sort of clunky with it. I say that with a red face.

Dawn: That's okay. If most people are like that, then we don't have to use it at all. So, I don't want you to feel badly about that.

Janelle: I'll try to nudge myself into the 21<sup>st</sup> century. (Fifth Study Group Session)

In addition to discomfort with the medium, in retrospect it is likely that some of the teachers perceived the creation of a written record of their questions and ideas for all to see and share electronically as riskier than simply sharing their ideas orally. Moreover,

even teachers who were not intimidated about sharing ideas electronically found that the listserv was not nearly as engaging or useful as the face-to-face study group discussions. For example, in concluding his first (and only) message to the listserv, Edgar wrote, “I personally like the personal interaction of our group better than the unresponsive reaction of my computer screen. (Not to discount the listserv – I just like creating and refining ideas WITH people better than the slower process of waiting for responses.)” (Listserv, 5/8/01) Finally, many teachers reported feeling overwhelmed and pressed for time. They barely had enough time to read other peoples’ responses, let alone compose their own. To make matters worse, school servers were frequently down, making it impossible to read or send electronic mail. These constraints, combined with the perceived lower benefit and increased risk, resulted in limited activity on the listserv.

Despite these limitations, the listserv did serve as a site for four substantive discussions of particular issues in mathematics education. I initiated the first such threaded conversation by sending a message to the listserv soliciting reactions to the Number & Operations Standard and the Teaching and Technology Principles. Over the course of three weeks, teachers responded to my questions, sharing their reactions to and questions about the document. Brian initiated the second substantive discussion after he and his partner, Mindy, returned from visiting another middle school and observing several mathematics classrooms. In his message, he posed various questions that had arisen during his observations, including the relationship between the NCTM *Standards* and school mathematics curricula, teachers’ and students’ reactions to and personal experiences with “math reform”, and the challenges of meeting all students’ needs in the classroom. This led to an online conversation in which teachers grappled with Brian’s

questions. I initiated the third substantive discussion by asking the teachers how they assessed their effectiveness as mathematics teachers on a regular basis. During the summer meetings, Tim initiated the fourth and final substantive listserv discussion by asking the group what types of questions they would ask applicants applying for a middle-school mathematics teaching position. Although the question seemed practical on the surface, it elicited teachers' values and beliefs about what it takes to be a successful mathematics teacher, as well as how they would use their new knowledge of *Principles and Standards* to assess the candidate's understanding of and stance toward mathematics reform.

The messages that constituted these four substantive discussions provided further insights into how teachers were thinking about the ideas in the document and about the particular beliefs, values, and priorities from which they were working. Thus, these messages were copied and pasted into four Word documents, one for each substantive discussion. These documents were then imported into the N5 database and coded for teachers' views of the document and for substantive issues. Table 13 summarizes information on the four substantive discussions – the discussion topic, the initiator of the discussion, and the number of messages within a discussion.

**Table 13. Participation in Substantive Discussions on the Listserv**

Discussion #	Topic	Initiator	N
1	Number & Operations, Teaching, and Technology	Dawn	6
2	Standards vs. curricula, mathematics reform, and student needs	Brian	8
3	Teacher efficacy	Dawn	4
4	Interviewing prospective middle school mathematics teachers	Tim	4

### **Summary**

In this chapter, I discussed the design of a research site, namely a professional development project, in which I could pursue my research questions. The process of securing funding and soliciting participants was then detailed. I then described the research design and the multiple data sources. Finally, techniques for analyzing the data were presented, and the notion of the cognitive demand of a discussion was introduced and elaborated. In the next chapter, I present results for research question #1.

## CHAPTER 4

### TEACHERS' DISCUSSIONS OF *PRINCIPLES AND STANDARDS*

This chapter addresses research question 1: When teachers are given an opportunity to form a study group and carefully read, analyze, and discuss an instructional policy document like *Principles and Standards*, what is the nature and content of their discussions of the document? I begin by presenting results from the discourse analysis of the study group discussions in terms of their level of cognitive demand. Next, I present and discuss three extended episodes from the teachers' discussions of the document in the study group sessions in order to provide more detailed snapshots of the teachers' conversations. Finally, I present results from the analysis of teachers' ways of viewing the document.

#### **Level of Cognitive Demand Afforded by Teachers' Discussions**

Recall that the study group transcripts from the first nine study group sessions were partitioned into conversational episodes characterized by a particular central theme. These episodes were then coded in terms of the level of cognitive demand afforded by the central theme and the level of cognitive demand maintained by teachers as they discussed the central theme. This resulted in each episode receiving one and only one of five composite scores: H-H, H-M, H-L, L-L, or N/A. Analyzing the teachers' conversations in this way provided one measure of the nature of teachers' discussions of and around the document. In particular, I employed the level of cognitive demand as a measure of the

*quality* of teachers' conversations, where quality refers to the potential for teacher learning afforded by the discussions. I hypothesized that conversations around central themes that posed and maintained a high level of cognitive demand would be more likely to engage teachers in the four stages of professional development proposed by Ross & Regan (1993).

Table 14 presents the results from the cognitive demand analysis. Column A contains the number of conversational episodes for each study group session. Column B presents the results of the coding of the cognitive demand of the episodes' central themes in terms of the frequency and percentage of central themes at a high-level or low-level of cognitive demand within each study group session. Column C presents the results of the coding of the level of cognitive demand maintained during teachers' discussions in terms of the frequency and percentage of discussions that were at a high, mixed, or low level, or were one-turn episodes (coded as "N/A"). Column D presents the frequency and percentage of episodes for each composite score category (pairing the cognitive demand of the central theme with the cognitive demand of the teachers' discussion of that theme).

What can we learn from the data in Table 14? First, note that the results in Column B indicate that the majority of the central themes initiated and discussed by teachers during the study group sessions were at a high level of cognitive demand (74% at a high level and 26% at a low level). Second, the data in Column D reveal that teachers struggled to maintain the high cognitive demand of these central themes during their discussions: only 24% of the discussions of episodes that began at a high level of cognitive demand were maintained at that level during teachers' discussions (H-H). In contrast, approximately one-fourth of the teachers' discussions began and were

maintained at a low-level of cognitive demand. The story is less discouraging if we consider high and mixed levels of cognitive demand simultaneously. In this case, 64% of teachers' discussions began at a high level of cognitive demand and at the least included significant portions of high cognitive demand talk. The data also reveal that one-turn episodes were rare, as indicated by fact that only 2% of episodes received a composite score of N/A.

**Table 14. Cognitive Demand Analysis of Episodes**

Session	A	B		C				D				
	# of Episodes	Theme		Discussion of Theme				Composite Score				
		HCD	LCD	HCD	Mixed	LCD	N/A	HH	HM	HL	LL	N/A
#2	23	18	5	3	8	10	2	3	8	5	5	2
#3	20	13	7	5	8	7	0	5	8	0	7	0
#4	11	7	4	3	4	4	0	3	4	0	4	0
#5	5	5	0	4	1	0	0	4	1	0	0	0
#6	10	7	3	3	4	3	0	3	4	0	3	0
#7	15	12	3	4	7	4	0	4	7	1	3	0
#9	15	8	7	3	4	8	0	3	4	1	7	0
#10	17	15	2	4	10	3	0	4	10	1	2	0
#11	13	10	3	2	6	4	1	2	6	1	3	1
Total	N = 129	95	34	31	52	43	3	31	52	9	34	3
% Total <sup>a</sup>		74%	26%	24%	40%	33%	2%	24%	40%	7%	26%	2%

<sup>a</sup>All percentages were rounded to the nearest whole number and so do not always add up to 100%.

Recall that in order to determine what role, if any, the document was playing in the teachers' discussions, each episode was coded as *document as catalyst*, *document as referent*, or *document-no role*. Episodes were coded as *document as catalyst* (DC) if the document, or a passage from it, had served as a catalyst for introducing a new central theme. Episodes were coded as *document as referent* (DR) if teachers directly referred to



or drew on the document during discussion of the central theme. Finally, episodes in which teachers made no reference to the document were coded *document-no role* (DN).

Table 15 presents the results from this analysis of the document's role. Column A provides the frequency and percent of episodes that were catalyzed by the document. Column B provides the frequency and percent of episodes for which the document was a referent. Column C provides the frequency and percentage of episodes for which the document played no observable role. Data within each of these columns has been disaggregated by cognitive demand.

**Table 15. "Role of the Document" Analysis of Episodes**

Session #	# of Episodes	A		B		C	
		D-Catalyst		D-Referent		D-No Role	
		HCD	LCD	HCD	LCD	HCD	LCD
2	23	12	3	1	0	5	2
3	20	7	6	2	0	4	1
4	11	6	0	0	0	1	4
5	5	2	0	1	0	2	0
6	10	1	0	5	1	1	2
7	15	6	0	4	2	2	1
9	15	7	2	0	1	1	4
10	17	7	0	1	0	7	2
11	13	7	0	0	0	3	3
Total	129	55	11	14	4	26	19
% by D-Code		83%	17%	78%	22%	58%	42%
% of total episodes (n = 129)		43%	9%	11%	3%	20%	15%
Total % <sup>a</sup>		52%		14%		35%	

<sup>a</sup>All percentages were rounded to the nearest whole number and so do not always add up to 100%.

What can we learn from Table 15? First, note that the document catalyzed approximately 52% of all conversational episodes, and that the majority of these episodes (83%) were at a high level of cognitive demand. Second, the document played some observable role in approximately two-thirds of all conversational episodes and no role in approximately one-third of the episodes. Third, the data suggest a relationship between the role the document played and the level of cognitive demand: as the document's role decreases (from catalyst to referent to no role), the proportion of low-cognitive demand tasks increases (from 17% to 22% to 42%).

Together, these analyses suggest that engaging teachers in a study of *Principles and Standards* can be a worthwhile and educative experience for them. The majority of the topics initiated by teachers for discussion were at a high level of cognitive demand, and for the most part, teachers were able to maintain at least some of their discussions at a high level. Furthermore, the document played a central role in either catalyzing or supporting these conversations. While these results illuminate interesting trends in the teachers' conversations, and suggest that the document does have potential to serve as a springboard into interesting and educative discussions, they do not do justice to the teachers' conversations. Thus, in the next section I provide "thick description" of three of the teachers' discussions of and around the document. I will also use these discussions to highlight some of the concepts and models used to analyze the data (i.e., episodes and central themes, dissonance, synthesis, cognitive demand).

### Three Windows into Teachers' Discussions

In this section, I present three extended episodes from the teachers' discussions of the document in the study group sessions. The first two are drawn from the teachers' first discussion of their readings from the document, which occurred during the second study group session. The third is drawn from a discussion of the Problem Solving Standard during the seventh study group session. Through analysis of these extended conversations, I hope to paint a picture of what teachers' discussions of the document were like. What did teachers talk about? In what ways did teachers participate? Providing detailed snapshots of these conversations is a contribution in and of itself, for as I discussed earlier, we know very little about how teachers might take up and react to a document like *Principles and Standards* when given the opportunity. These episodes also reveal that as early as the second study group session, teachers participated in the discussions in different ways, and these different patterns of participation afforded or constrained the group's opportunities to learn from the discussions.

Moreover, these episodes have been chosen to highlight three of the important themes that emerged from the teachers' study of the document and that were frequently revisited by teachers, not only in later study group sessions, but also in other venues such as their dialogue journals and their conversations on the listserv. The first theme is the notion of teachers being able to assume that students have mastered certain mathematical skills and concepts, so that they can move on and introduce students to more advanced topics. The second theme addresses what is meant by *equity* in mathematics education. The third theme addresses what is meant by *problem solving* in mathematics.

### Assuming Mastery and “Moving On”

One of the first substantive issues taken up by teachers was a recommendation put forth in Chapter 1 that teachers should be able to assume students have achieved mastery of certain skills and concepts and “move on” to newer, more advanced mathematics.

School mathematics programs should not address every topic every year. Instead, students will reach certain levels of conceptual understanding and procedural fluency by certain points in the curriculum. Teachers should be able to assume that students possess these understandings and levels of fluency when they plan their mathematics instruction. (NCTM, 2000, p. 7)

As early as the second study group session, several teachers in the group took note of this idea and began to grapple with what “moving on” really meant, when it was feasible to do, and what role, if any, equity played. This issue resurfaced quite frequently in later study group sessions and in teachers’ dialogue journal entries. Carla was the first teacher to initiate a discussion of this issue in the study group sessions.

Carla: I guess I was going to say something and it was right at the very, well at the bottom of page 7. And I guess this is a dilemma and it seems like as the years go on for us, it just seems to get worse. It says, “Teachers should be able to assume that students possess certain understandings and level of fluency when they plan their mathematics instruction.” So, there’s the assumption that they have learned the multiplication tables. And I guess when I went to that workshop Friday that was another thing where evidently, and I think he was talking about Japanese schools, where they give the parents what things kids need to know, certain things. And it’s almost like the family has been insulted if they don’t learn it, which is certainly not happening, not in our district anyway!

Brian: I also highlighted that. I’m wondering what is the role of review. We always have to keep reviewing the algorithms. And just over the summer, you can see a huge difference. And they’re not valued and they’re not practiced or something... And they’re like, “Do we need a common denominator?” And I’m like, this is eighth graders, they’ve been doing it for three years!

Carla: Well, even when eighth graders get to the point where they’ve been using their calculator for so long and then you give them something,  $-5 +$

7, and they've got to whip that out like they can't even think. It's habit. I think they know it. It's just habit.

Edgar: I've seen it in high school, the same thing. They've got the big TI-82's and they can't do arithmetic because they're wholly calculator dependent. Not all of them, but a frightening number of them.

Lara: Well, there's... this is totally off the topic, but it's something that came up in our class the other day. We were working on something and trying to find the rate of change of something and we came up with it, but it was 0.666, so it's repeating. And we had this big discussion about the fact that when I went through school, we didn't use calculators so the first time when I made up the stuff, looking at the average rate of change in the tables, it never occurred to me that the answer wouldn't be a fraction. I mean, and I found out all kinds of things that I didn't want to know about changing fractions to decimals on a calculator. (Second Study Group Session)

In this first clip, we see Carla initiates a discussion by quoting a particular passage in the document about the need for teachers to assume mastery, an instance of the document serving as a catalyst for the episode (document as catalyst). Brian then builds on Carla's comment by posing a related question about the role of review. This then transitions into a discussion of the tendency of students to forget some basic mathematics skills and procedures and become dependent on the calculator. Lara then shifts the discussion, sharing a story from her own classroom to illustrate the implications of using calculators, and recognizing aloud that "this is totally off topic". In doing so, she manages to temporarily reduce the cognitive demand of the discussion.

After a few teachers briefly react to Lara's story, Kayla shifts the conversation back to the issue of assuming mastery and moving on.

Kayla: I interpreted that as a little different. We set about in [Clarksville] a hundred-million years ago to look at math differently with the old *Standards*, looking at whether or not for our program – this was a main focus – that we should be able to assume certain processes knowing that they won't have it all perfect. They won't have mastery, but we should be able to assume that they have certain processes there or otherwise our

sixth, seventh, and eighth grade curriculum never would have changed because we used to spend three months in sixth grade doing adding, subtracting, multiplying, and dividing and we would never get to any new material. So, this was actually a huge focus, I guess it was 9 years ago or 10 years ago that we started looking at change. We had to assume certain things. We had to assume... It was set in stone that when kids come to the sixth grade they will know adding, subtracting, multiplying, and dividing. Knowing not everyone does, but it was an expectation and that was not going to be a subject taught, even though we have to do maybe some trial work here and there and work on some problems here and there. Or, right before *Prime Time*<sup>1</sup> doing something or during *Prime Time*, but it wasn't going to be a unit of study. And our high school does the same thing. Fractions are not a unit of study anymore in high school. That was a main point of ours to... So, I guess I don't look at it as mastery, but if I don't assume they know some things then I can't move forward.

Brian: I think that though if you read the literature about what happens to teachers that they get in trouble with parents because quite often it's because they say, "Well, we taught them fractions" but they never do them again....

Kayla: Right.

Brian: ...and I guess we have. I don't feel that was very much addressed in this. Is there a role for review? If there is at all... or do we never review you just assume that they have it and if that's the case then should you [inaudible] You have kids that have to have it at least a couple times a month.

Kayla: Right.

Brian: That was interesting to me. [Introducing new central theme] Also, on page 6, the second paragraph "although there will never be complete consensus"... I love that. There has been an awful lot of controversy, not just in our school district, but within what should be taught and what shouldn't be taught. And I think years of fighting about it has given us a new strength and conviction. I don't know if the rest of you had the same reaction to it.

Monique: We've all been taught by and large that, "Students just aren't developmentally ready for that yet. I don't know why you're trying to teach them something they aren't developmentally ready for!" But yet in this book, you know, my 18-month-old daughter should be able to at least put

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<sup>1</sup> *Prime Time* is one of the sixth grade units from the Connected Mathematics Project (CMP) curriculum used by Kayla and several other teachers in the group.

things in patterns, which are the beginning steps of algebra. And I know she can do it; I watch her do it. I know she can put her blocks red, blue, red, blue, red, blue. So, if they're calling this algebra and my 18-month-old daughter can do it, it just baffles me that "6th and 7th graders just aren't developmentally ready." Yeah, they are, we just need to start them earlier and call it what it is. (Second Study Group Session)

In this second clip, we see Kayla and Brian attempt to redirect the conversation back to the issue of assuming mastery and moving on. Again, Brian asks about what role review should play, indicating that this is something he is struggling with and feels dissatisfaction about (suggesting dissonance). Brian then poses a new passage from the document for consideration (initiating a new central theme), but it is not immediately taken up (resulting in a one-turn episode). Rather, as in the first clip, the discussion quickly shifts away from this issue, when Monique comments on students' readiness for algebra. Like Lara, Monique draws on her own experiences (in this case, with her daughter) and tells a story to support her argument. Finally, note that Kayla discusses how teachers in her district have used the previous *Standards* as a tool for revising their mathematics curriculum.

After a few teachers comment on Monique's story, Brian redirects the conversation, and the teachers again take up the idea of assuming mastery and moving on.

Brian: Well, anyway, it was kind of interesting for me to read that second paragraph on page 6 because I had not thought about, I mean I've read this before, but I completely skipped the first chapter because it was long. So, to have actually be forced to read it I could see that. But that second paragraph – to say that the role of this whole document is to initiate discussion in the arena of a lot of controversy... So, it's not like they're taking a stand one way or another necessarily, but trying to pull out some ideas and get people thinking, which I think that's perhaps not always interpreted (*inaudible*)...

Lara: Well, and sometimes I think that takes a lot of trust because this is only my second year teaching, but you know you kind of go in and you're like, in some senses you feel like you can save the world. And in some senses it's like pushing against a brick wall—you're not going to get very far. But, I just went in there and assume that they have it and they're like, if they don't then we just kind of touch on it then instead of spending a month on going over something like that. It's a sense of trust; you have to kind of trust that they really did cover what they were supposed to cover. Unfortunately, what I also found out with what I'm teaching this year is that that trust is also, has to be built on the fact that you're going to cover certain standards in your classroom and so if you just choose not to teach them, then those children are kind of being deprived of getting what they're supposed to get.

Janelle: I make no assumptions of mastery whatsoever. The one thing that I think really helps within buildings and schools is if people communicate very, very well what it is that they do so that as students come to me or to any of you. You know, you can be pretty solidly founded on what has been introduced at least. To assume mastery, I think, for me anyway, is wrong. I have a high percentage of kids who haven't mastered things. So, I don't make that assumption, but I do want to know and I think that's part of my goal in this as well as understanding aligned curriculum that if you're communicating well in your district what other people have done and what you're doing then you know what has been introduced so you have a starting place. And what I do in my own classroom – in a way, it's remediation – but I kind of look at math as a thing that goes like this as it swings forward it kind of goes back. So, what I do is I kind of use the past skill, but I don't assume that they've mastered it, but I use that to hit the new things, which for every child, no matter whether they know their multiplication tables or not, is exciting. And I have kids really excited who don't do adding and subtracting very well. So, what I try to do is introduce the really exciting stuff, but keep twirling back around toward basic things so that I catch, I keep grabbing, the ones that haven't mastered yet, but it's all under the guise of "the new stuff." And, it seems to work on a number of different levels, I guess. (Second Study Group Session)

In this clip, Brian picks up on another purpose for the document, namely as a springboard for discussions of controversial issues in mathematics education. Lara argues that assuming mastery requires teachers to really trust each other and recognizes that she has a responsibility in that, too. Janelle takes a different stance on the issue of assuming mastery, clearly disagreeing with the comments shared earlier by Kayla and Lara. "To



assume mastery, I think, for me anyway, is wrong.” By offering an opposing perspective, Janelle provides teachers with an alternative to consider, and provides an avenue for teachers to debate the issues (supporting dissonance).

This willingness to disagree and posit opposing points of view reemerges in the next clip, in which the discussion shifts to considering the issue of mastery in terms of computation and basic math facts.

Joyce: Well, I want my kids to sit down and multiply and divide and add and subtract without my help. And, I’m kind of struggling with that right now with this low class that I have because we’re still working on basic computation with these kids. And we’re trying to do more than that, too, but if they can’t do basic computations and we’re trying to teach them area and perimeter, they’re not going to come up with the right answer because they didn’t add right or they didn’t multiply right or something like that. So, what do we do? Do we get to a point where we just say they’re not going to be able to multiply two-digit or three-digit numbers? So, from this point on, we’re just going to let them use calculators and that’s ok? That’s a legitimate question to me. I don’t know. Maybe that, do we reach a point where we do say that they’re not going to be able to do pencil and paper, so we’ll move them to a calculator because we need to teach them these other concepts that they need to know?

Edgar: Or, do we keep starting in September teaching two- and three-digit multiplication? I’ve got kids in my regular classes, not the low kids, I have kids in my regular classes, who...

Kayla: In what grade?

Edgar: Eighth grade... who will not work on paper and pencil [tasks]. Right now, I’m missing a calculator or two from my classroom set so one way I’m trying to encourage its return is by only putting out the one tray of calculators that’s not full, rather than all four trays of calculators for the whole class. And lots of them have their own calculators, but the number of calculators that are available to borrow has been reduced since a couple of them are missing. So, there’s not quite enough to go around so some students are left and they’re sitting there trying to finish a problem and they’re not working. And they’re looking around and talking and I call them on it and they say, “Well, I need a calculator.” And I say, “Well, what are you trying to do?” And they say, “Well, I have to multiply these numbers.” “Well, do it on paper.” “But I need a calculator.”

Tim: (*Speaking passionately*) You can tell by all the steps that they've taken that they understand the mathematics behind it. So, I don't think it is a big deal if they don't know how to multiply 2-digits on paper. It takes a long time to do that anyway and once they get to a certain point where, we're all middle school teachers here, I don't care if they multiply stuff out or divide stuff out. I'm not going to sit there and keep re-teaching them the stuff that they should've learned two and three years ago. I say it's my job to teach the higher levels of mathematics that are being taught in the seventh grade, not how to divide over again. If you didn't learn how to divide, we'll have several examples throughout the year where division takes place. You can try it. I can try to help you with it; you can work on it at home and whatever like that. But we're not going to stop class and do two weeks of re-teaching division, re-teaching how to multiply three-digit numbers and all this other garbage...

Mimi: Well, I think that's part of it though, because I think once they know what that process of multiplication is—that 5 times 3 is 5 sets of 3 things, going back to your area calculation. Then eventually they have to know for algebra that  $5x$  is 5 groups of  $x$  things. But whether... You can't belabor these. We have some very, very bright seventh graders that I've worked with who can't even do two-digit, I mean, the memorized math facts 9 and 8 and they're dotting it out and counting and adding on and counting on. To belabor that to that child is a great disservice – if he can't go on until he knows all those facts. (Second Study Group Session)

From this interaction, we see that even early on, the teachers were willing and comfortable to propose different points of view and values. Janelle asserts that she does not assume mastery; Joyce admits that she wants her students to know the basic facts and works with them on these. In stark contrast, Tim refuses to re-teach multiplication, arguing that it does not belong in middle school. Mimi makes a connection between assuming mastery and equity when she states, “To belabor that to that child is a great disservice.”

Discussions like these, in which teachers are grappling with a complex issue and offer multiple perspectives and opposing stances, are rich environments for catalyzing dissonance. As teachers share their own stance on mastery, they are becoming more

aware of their own beliefs and priorities. By being exposed to opposing viewpoints, teachers are provided with alternatives for consideration, allowing for synthesis.

### **What is "Equity" in Mathematics Education?**

Although Mimi and others alluded to equity issues in their discussion of whether or not teachers should assume mastery or move on, Kayla was the first teacher to explicitly address the Equity Principle. In the next extended episode, teachers' discussion of the Equity Principle, and more generally what equity means for mathematics education, is traced.

Kayla: Well, I think equity is a huge one because it's one that we wrestle with in our district all the time. Do we really believe as a district that mathematics can and must be learned by all students? Or is it for a few? It's a major discussion all the time in our district. When we made a decision eight years ago to un-track our middle school completely, but it's still revisited every year. Did we make the right decision? If we did make the right decision to un-track, are we meeting the needs of all students? Are they all receiving the level of mathematics that meets their needs, but still pushes them forward? You know, all of that. I think it's a huge principle.

Monique: Do you find it harder un-tracked?

Kayla: Un-tracked? Yeah, but I would never go back to tracking.

Monique: Really?

Edgar: How are you defining tracking? Because this came up in our talks... There are a couple of teachers who are really sticklers on how they use the word because there's a difference between tracking where kids are in a program where this leads to this, this leads to this and if you're not in algebra in eighth grade you will not be in a calculus or an AP class. And there's the idea of having of different levels going on at the same time where you could be in this or this or this and we have classes for kids who need a little slower pace and we have classes for kids... but you can jump tracks. Some teachers wouldn't call that tracking. That's not tracking. Tracking is when you have things and you don't switch between them. If you've got different classes so eighth graders can be in different places or

tenth graders can be in one of three different places, but they can move from one to the other. That's not tracking. And some people would say, "Well, we have different classes, we have different levels, so that is tracking kids into different..." So, how are you looking at tracking?

Kayla: I guess when you're stuck in a...

Edgar: You're stuck in a rut.

Kayla: I'm from a small district where you don't have a lot of options.

Edgar: Your future is predetermined by the time you start middle school.

Kayla: Right.

Lara: Right. And when I interned I had tenth graders and seniors and it's pretty sad when you hear a kid that's doing very well in your class say, "Well, my teacher said I was too dumb so I had to do a two-year trans-math class to be able to go into Algebra I in tenth grade." And I really, I didn't spend too much time at the middle school in Hanover so I didn't see what it was. But when a student feels like "I'm too dumb" - so in a sense they're only being offered Algebra I in tenth grade - it is kind of disheartening to hear because you know that there are concepts there that they can understand. But then again, you go along that question about computation, you know what's going to make you decide if they can take it or not. And, like you said, is it equitable if they can't necessarily add, subtract, multiply, and divide 100% or 85% that they can't go into Algebra I and then they have to do another year the same thing that they did the year before. (Second Study Group Session)

In this clip, Kayla initiates the discussion by sharing that she struggles with what equity means for her classroom, and admitting some uncertainty about the district's decision to un-track classrooms. In Monique's response we begin to see a possible distinction between ways of participating in the study group discussions. Kayla's initiating comment, in which she wonders aloud what equity really means for her district, seems to be of a different nature than Monique's response. I argue that Kayla's turn is more productive for the group's discussion for two reasons. First, the questions Kayla asks are substantive and complicated. Grappling with what it means to be equitable in a

heterogeneous mathematics classroom is not a simple issue; it requires a consideration of many issues and an examination of one's priorities and beliefs. Second, Kayla's musings are open for anyone in the group to respond to. For these reasons, Kayla's turn has greater potential to guide the group's discussion in potentially fruitful directions (high cognitive demand, supporting dissonance). In contrast, Monique's response is a question that can be answered with one word ("yes" or "no"), and can only be answered by Kayla. In this sense, I argue that Monique's contribution to the discussion *constrained* the group's opportunities to learn from the discussion (low cognitive demand).

A similar distinction can be made between the interactions between Kayla and Edgar, in which they work to negotiate a shared definition of "tracking", and Lara's turn, in which she shares a particular story from her own experience. Edgar pushes Kayla to specify what she means by tracking, implying that perhaps not all forms of tracking are inequitable. Although he directed the question to Kayla, his query – "How are you defining tracking?" – opened up a substantive issue that all of the teachers in the group could reflect on and consider (high cognitive demand, supporting dissonance). Moreover, simply by listening to Kayla and Edgar's negotiation of what is meant by "equity", the other teachers are exposed to potentially new perspectives on tracking and equity. In contrast, Lara's contribution shifts the conversation to a story about one of her past students. Although her story seems at least tangentially related to the central theme under discussion, her story does not really invite other teachers to respond. Their primary role is to be a listener to Lara's story. However, by the end of her turn, Lara does succeed in bringing the conversation back to assuming mastery.

The group revisits these questions about equity and tracking later in the discussion.

Kayla: I guess that's why I thought this was really hard for me to read this. I read the Equity Principle and it passed [met] my expectations for all students and I agree with all this. But I thought, "What does that mean in my classroom? In my district? In my building?" And I'm not saying that un-tracking is the answer either. I'm just saying, "How do I make that work?" If that's the stance our district has taken that that's what equity means, then I don't know. I wrestle with it all the time.

Janelle: Well, I don't think that equity means "sameness" either. It's always going to be real gray and as I listen to the different ways in the room here I think, I see reasons that I guess are good for lots of different things: for tracking, for not. And so to me it is going to be gray and tricky. The idea of equity is a real big "-ism". It is a larger kind of thing and I think the discussion, the dialogue is always going to be there. I personally think there's no right way, but I personally, I like to do it your way. And I'll stick my neck out. I like the idea in my classroom that I have some people who probably would be comfortable at the third grade in terms of what they're doing and then I have others who would do okay in the high school and they're all in my room. And for me to make the whole circus, and I don't mean it in a negative way, but the fact that there are lots of rings going on, that's my challenge. But I think they all seem to benefit. So, even though it's not perfect for the very talented student who might be teaching somebody one day instead of getting more that is real cool for him, somehow I think it's the better thing. And again, I see it's 55/45 [percent] or one day it's 45/55. But that's my gut and my take on equity as well.

Kayla: The whole curriculum that helps with that though. [Without it] I couldn't do it. And I don't do it well. Six years working on it in this building. But, to have a curriculum that allows kids that are up here to do it up here and not just helping the kid down here all the time, I mean, they do help the kid down here, but to be able to... Maybe this kid is going to solve it symbolically all the time and this kid is going to draw a table and still get a 58 out of 50 or something. I have a curriculum to help me do that also helps, because I couldn't do it before at all, I still don't do it well. But I still don't know... does that... What does it mean that, "Mathematics can and must be learned by all students"? Does it mean that they all have to learn it at the same time, at the same level, or just.... You know I don't know what it means and I struggle with that all the time. Am I being equitable or am I just getting through another day?

Dawn: I don't think it means at the same level or at the same time, which I see a lot of people going, "Oh no, not the same time," but the same math for everybody.

Kayla: Right. Because this kid does it with a symbol and this kid does it with a table and they're still doing the same math because the answer to the problem is 29.

Tim: I was going to say – I interpreted this Equity Principle not to mean that all the kids come out of your class knowing the exact same thing, but that they all had the opportunity, they all had the chance to learn it at the same time in whatever kind of way they needed to. And I just can think of a couple examples of... I was in a gifted program when I was in middle school and they pulled out whoever had higher test scores. I don't know. And they stuck us in here and there was probably fifteen or twenty of us and so we were there I guess because we could learn things faster or we could do more advanced things or so we wouldn't be bored or whatever this garbage was they were feeding us. So, one of the things they did that I can remember was for our science class we did a bug collection and we learned about bugs this way and whatever it was and we pinned them all down. And I was thinking, "So, all the other kids in the seventh grade wouldn't have enjoyed collecting bugs?" They could have learned the exact same thing. I mean, I'm looking back on it now and I think it was totally stupid. We had to do a leaf collection. Well, why couldn't the other kids who weren't as "gifted" as we were do a leaf collection and learn about leaves that way? Why did they have to read about it out of a book or... I don't even know how they did it because I wasn't there. But they weren't doing what we were doing because we had to be separated to do that.

Lara: And they may have actually benefited more from doing that than you did.

Tim: Yeah. I'm just opposed to anything like that. Why were we learning it in a different way? It didn't make any sense to me. You know, they don't want us to be bored. Well, what? You want everyone else to be bored?

*[Laughter]*

Janelle: That's right. Everybody's gifted and talented, aren't they?

Tim: I think so.

Janelle: I do, too.

Tim: I do. I think it's terrible. And as far as like in my class, I have all different levels of students, but we do certain math problems and I'll say, "Okay, figure this out." I don't really tell them what to do. And then they have some time to work on it and I say, "Okay, everybody show what they did." We get like five or six different ways to solve a problem and they're all correct and they're all legitimately different ways that people thought about it. And I always tell them, "I don't care how you do it, as long as it makes sense to you and you can explain it, then you did it right. And you know what you're supposed to and that's that. You don't have to do it some advanced way." The brightest kid on my team came up with a really clever way to solve the problem and then I have another one who's doing  $50 + 50 + 50$ , like some people have been saying, but they got the same answer and they both got different things out of it. And you didn't have to separate any of them and say, "You're not allowed to have any fun or you're dumb, so you can't do this." And I just get sick when I hear things like that. I don't view it as being a problem like that.

Kayla: Do you feel that that's an equitable situation for all levels?

Tim: I think the Equity Principle means you don't say to a certain group of kids, "You can't do it this way." You don't say that to them.

Kayla: You have an expectation of this mathematics or this concept and however they get there.

Tim: However you get there, you get there.

Kayla: And so that makes it equitable?

Janelle: I had a....

Kayla: Because of their level?

Tim: That makes it equitable... (Second Study Group Session)

In this discussion, Kayla reintroduces the questions she is grappling with about what equity is and how to achieve equity in her classroom (high cognitive demand theme). By posing challenging questions to the group and admitting she is struggling with this issue, Kayla invites others to take up these issues and help her grapple with them. Janelle responds by explaining her stance on equity, arguing that there are no easy answers to Kayla's questions and that equitable is not the same as equal. Again we see Janelle



willing to take what she sees as a possible risk (“And I’ll stick my neck out”) by admitting she prefers for her class to not be tracked. Kayla responds by observing that her mathematics curriculum supports her in establishing equity in her classroom. She then reframes her questions, soliciting additional feedback from the group (maintaining high level of cognitive demand). Like Janelle, Tim argues that equity does not mean “sameness” and provides his own definition of equity. He supports his argument by conveying two stories about past experiences.

### **Key Features of Teachers’ Early Discussions**

Analyses of these two episodes and others indicate that a few key features characterize teachers’ early discussions of the document. First, as I anticipated, teachers often “tell stories”, sharing examples from their own classroom or life and drawing on them to make sense of the ideas under discussion or to support an argument they are trying to make. In other words, teachers make sense of the ideas presented in the document by connecting them to what they already know. Second, early discussions like these are characterized by frequent shifts in topic, in which teachers do not always immediately take up and build on ideas or questions posed by others. The discussions do not develop cleanly, but rather in “stops” and “starts”. Sometimes teachers try to build on and pursue a proposed idea; at other times, they switch gears and introduce a new idea. Despite this, we do see the teachers revisit the notion of assuming mastery and moving on several times throughout the discussion. Thus, early discussions like those presented above suggest that from the beginning, teachers were capable of identifying and then grappling with important issues presented in the document.

Indeed, the teachers' ease in and ability to engage in an extended discussion of ideas presented in the document is particularly noteworthy. Recall that these two episodes took place during the second study group session, before the teachers had had much chance to get to know each other or myself. For most of them, this was the first time they had even read the document, let alone shared their interpretations of it in a public forum (with tape recorders and video cameras capturing their every word). Given this, I expected that teachers might feel somewhat intimidated in the beginning and be reticent to speak up. They might also be reluctant to disagree with each other. I also worried that the teachers might not find the readings worthy of discussion. Perhaps the document would be too far removed from the needs and interests of classroom teachers. The group was meeting in the early evenings, after a full day of teaching; they were tired. Perhaps the document would not be able to engage teachers under these conditions. Given this, I had anticipated that I would need to provide a lot of scaffolding of teachers' discussions in the early sessions. And yet, during this first session, the group maintained a lively discussion of the document for the full three hours, with little support from me. Some of the teachers also exhibited a willingness to take risks, disagreeing with each other about the importance of basic skills and when or whether to assume mastery and move on.

This seems to support the notion, presented in Chapter 1 of the document and identified by Brian, that one purpose of the document is to "stimulate ideas and ongoing conversations" (NCTM, 2000, p. 6). In the episode discussed above, we see the teachers use the document as a springboard into discussions of important issues. Carla's reference to a statement in Chapter 1 about the notion of assuming mastery and "moving on" catalyzes the group to grapple with how to interpret the document's recommendation,

using basic (multiplication) facts as a specific case to consider this notion. The role of calculators in relation to basic facts is also taken up. Underlying this discussion are attempts to make sense of how the Equity Principle intersects with these ideas. When it comes to basic facts, what is more equitable – insisting students know their multiplication facts before letting them move on, or letting students use calculators so that they can experience more advanced mathematical ideas?

### **What is Problem Solving?**

This next clip comes from the seventh study group session in which teachers discuss and analyze the Problem Solving Standard (Chapters 3 and 6). Brian posed the question, “Is problem solving a skill that can be taught?” This led to a lengthy and passionate discussion of whether problem solving is actually mathematical *content* to be taught, or if it is a *process* through which students learn mathematical content.

Eventually, the group takes on the question, “What *is* problem solving?”

Edgar: And if you ask the question is problem solving something that can be taught, I’d almost have to say well of course it is because that’s one of the things that the *Standards* is saying that we need to start giving our children and letting them practice it and you know, get more fluent. And if it’s not, if you take the opposite view and if it’s not something they can be taught, then you are dangerously close to having no other choice than to embrace the idea that some kids are natural-born problem solvers and other kids are not. And then that almost becomes part of the Equity Principle. Are we saying, are there some kids who can’t get math and can get math based on their natural problem solving abilities? So, in answer to the question, yeah, it’s probably something that can be taught. It just needs to be fostered or given a chance to be practiced.

Mindy: I also think though that the teacher themselves, they need to feel a need to teach it, because, for example, Brian and I taught a statistics unit. And I was dreading life when I was teaching it, and I didn’t like it, and my kids as a result didn’t like it. They thought it was stupid, easy, and boring. And he was just loving life as everyday and he taught it in this wonderful

way. And his kids loved the packet. And I was just like, why in the world? And then I was thinking that maybe it was my attitude – let's just get through this! Come on, we've got a week! But, I really think that days that I feel really rushed and I don't like let them show all their stuff they do not solve it in as many ways and they don't show as many steps. And the days that I devote the whole day by doing one problem as many ways as possible, you know, that's when I see them thinking more and trying. So, I think it, well, I wear my emotions on my face so, the kids can really read me well, but I think the bet is what I value, they typically value. And when I don't value something, they typically don't.

Brian: And it's not just what you wear on your face, it's how you structure your class.

Mindy: Oh yeah, that, too.

...

Dawn: So, I'm hearing ideas about I think what makes a problem a *good* problem. That seems to be what you were talking about. But I want to know how do you know when you see something that it's problem solving? What does it need to be, for you to go yeah, that's problem solving? Now we're doing problem solving.

Edgar: Making sense of a problem and understanding not only, well understanding the answer and everything that means. Understanding the answer, what the answer means, where the answer came from, what you did to get the answer.

Dawn: So, if the kids don't understand the answer at the end, it doesn't make sense to them, then it's not problem solving.

Edgar: Just a moment please! (*Flipping through the document*)

Mimi: Page 52, right at the top, first sentence. "Problem solving means engaging in a task for which the solution method is not known in advance." So, for number one, before you taught an algorithm and if you throw that at them, it could be problem solving. But after they had the algorithm, then it wouldn't necessarily be problem solving.

Edgar: I had a different page, page 260, the bottom.

Dawn: Ok. I don't want to lose, we can go to Edgar, but I don't want to lose what Mimi just said.

Edgar: In addition to that, and I didn't mean to drop you off and say no, that's not what I want, but I had another place as well that, at the bottom of page 260, "For several reasons, students should reflect on their problem

solving and” blah, blah, blah, blah. The last sentence, the last sentence on that page, “Students should understand that the problem-solving process is not finished until they have looked back at their solution and reviewed their process”.

...

Monique: I think problem solving is just figuring out how to do it. Just like my daughter, she’s almost two and she loves to watch Pooh and she can’t just put the tape in the VCR. But I can, so it’s not any thinking on my part, but when she struggles to try to get her Pooh tape in the VCR. You know, she’s problem solving. She’s got it upside down, she tries to put it in sideways, she tries to turn the VCR on. I mean, she’s having to think or struggle through to get it.

Dawn: So, that’s kind of getting at this (*pointing to the board*), you don’t already have a solution for it, which is what that line is that we read in the document.

Brian: What if you had an algorithm, but it’s buried, you have a whole pile of other algorithms and you get a problem, and you can’t remember which algorithm it is, but you know it’s one of those? Is that problem solving?

...

Mindy: I would also say that if you took the first equation  $4x + 2 = 10$  and you asked the question write a story problem for this, I would say that’s problem-solving and that doesn’t really require an algorithm.

Dawn: So, why is that problem-solving?

Mindy: Why is it? Because it’s forcing them to think about that problem in a different way and make sense of it, but they should know how to do it, but I would still say that’s problem solving.

Dawn: So, novelty is part of it? Because I’m wondering if the students did know how to do that, they were used to always writing problems for equations, story problems for equations, then would it not become problem solving after they’re used to, they’re so familiar with it that it’s almost second nature for them to do it? Apart from the fact that it’s novel and something new that they haven’t really tried before that makes it problem solving?

Mindy: I don’t, for my students and maybe I don’t do it enough, I don’t think that they would ever be extremely comfortable, but I think it’s just very difficult for them and that’s why I guess I would consider it problem-solving because of the difficulty, because they have to struggle through getting that solution.

Dawn: So, it has to be challenging, to be problem solving? (Seventh Study Group Session)

In the previous episode, we saw the document serving as a springboard into a discussion of the notion of assuming mastery and moving on. In this episode, we see this, as well as another type of engagement with the document. The document not only serves to provoke a discussion of problem solving, but is also used to provide initial guidance or “answers”. Both Edgar and Mimi turn to specific passages in the document to answer the question, “What is problem solving?” However, it is important to note that the group does not simply accept the document’s stance. The discussion does not end with Edgar and Mimi’s quoting from the document. Rather, the group continues to wrestle with the question, again considering a variety of perspectives and possibilities. Although the group was unable to achieve a final consensus, individual teachers later reported that this discussion helped them to be explicit about and clarify their own ideas about what it means to engage in problem solving in mathematics (supporting dissonance).

This episode is characteristic of the study group discussions in general. Teachers took up substantive issues that were addressed in the document, recognized the complexity of these issues, and exhibited willingness to grapple with them, rather than reduce them to easy answers. Unlike past studies such as the R<sup>3</sup>M project (Ferrini-Mundy & Schram, 1996) that found many teachers interpreted “doing” the *Standards* to mean using manipulatives or group work, these teachers did not tend to over-simplify the document’s messages and recommendations.

### Teachers' Views of *Principles and Standards*

I now turn to a discussion of the perspectives from which teachers in this study came to view the document. By teachers' "views" of the document, I mean their ideas about the document's nature, purposes, and uses. Analysis of the study group transcripts and journal entries revealed that a broad range of perspectives arose within the group, and that individual teachers were capable of assuming multiple perspectives. Five main categories of perspectives were identified and will be discussed in this section.

#### The Document as a *Warrant*

One of the most common perspectives assumed by many of the teachers was that of the document as a *warrant*. From this viewpoint, teachers envisioned using the document to defend their current beliefs or practices. One way that many teachers saw themselves using the document as a warrant was in defense of decisions they had made about the use of calculators in their mathematics teaching. For example, consider the following exchange that took place during the fifth study group session.

Brian: Ok. I'll risk it, I'll say it. I liked on p. 32, "When teachers are working with students on developing computational algorithms, the calculator should be set aside."

Janelle: I agree with that, too.

Dawn: Where is that, Brian?

Brian: It's on page 32, at the very bottom.

Dawn: At the bottom?

Brian: Yeah, the last sentence. I guess I saw it as *giving permission* [italics added] to do some back to basics type of instruction, or what would be seen as back to basics by the parents. I know that there's always a sigh of relief at open house when I say, "And some of the times this year your

kids will not be allowed to use calculators. Please look out for that and don't let them." "Oh, yeah," they'll say. I'm sure they...[inaudible] too, but, I guess it's reinforcing, or reassuring to know that they're going to have that every year.

Dawn: What did other people think about that? This idea that there should be times when they [students] can't have a calculator?

Mimi: Well, we have parents who think that they use them too much. So, this kind of sets up parameters for facing the reality that, you know, they do address that it's a commonly used computational tool outside the classroom, and your classrooms should reflect that. So, it kind of sets up a parameter for our parents to understand... (Fifth Study Group Session)

In this passage, Brian identifies with a particular statement in the document regarding the appropriate use of calculators. He sees this statement as giving him "permission" to put the calculators away when he was helping his students develop their computational abilities, a practice already in place in his classroom. Mimi interprets the passage, and my question, a little differently, considering how the document can be used to defend what parents see as an overuse of calculators in their school.

Both Brian and Mimi are viewing the document as a sanction for current practices in their classroom. However, their intended audience differs. While Mimi envisions using the document to validate calculator use to parents, Brian seems to viewing the document's statement as validation not for parents but for him. His students' parents already approve of his setting aside time where calculators are not allowed. The document simply confirms that he is doing the right thing.

Mimi continued to explore this notion of using the document to defend their use of calculators in mathematics instruction.

I do know that in reading the selections, I was certainly encouraged, especially in regard to the calculator use. I can use segments with this parent (and others) to clarify the issues, knowing that I have, in this document, the support of a large body of educated mathematicians and



educators. "Calculators should be available as appropriate tools, particularly when many or cumbersome computations are need to solve problems. However, when teachers are working with students on developing computational algorithms, the calculator should be set aside to allow this focus (p.32-33)." The document did repeatedly speak to the use of calculators and computers as tools that are a reality in the home and the workplace, and we cannot be considered responsible and simultaneously not use these tools in our classrooms. (Mimi, Third Journal Entry)

In this passage, Mimi identifies and aligns with one of the document's arguments for the use of technology, namely that technology is so widespread in today's world that it would be unjust to not teach students how to use it to learn mathematics. Again, she foresees how the document can be used to make a case to parents and "others" (later identified as administrators and other mathematics teachers) for the importance and appropriateness of calculator use in mathematics instruction. Implicit in her use of the document in this way is the assumption that parents and others will recognize the NCTM as an authority and find the document incontrovertible. For example, in preparing for our NCTM presentation, Mimi shared the following story.

Additionally, the high school where approximately two-thirds of our students attend did have a math meeting to explain the changes in their program. This meeting was for eighth grade faculty, and I was in attendance. ... I did bring up the document at that meeting, as they are not allowing students to use calculators at any level in the freshman courses. I want the high school staff to know what we are doing, and where we are going. Although frustrated in my attempts to find justification for this policy, I was encouraged by support of another teacher who stated that our students are living in a technological culture, and to deny them the tools to work within this society, we fail to prepare them properly. Defensively, one high school teacher stated, "Since we are a private school, we don't have to pay attention to those documents and standards." Ahh, yes, there is still work to be done, but I know that I am backed by educators and professionals who see value in this document and recognize good teaching practices. (Mimi, NCTM Homework Assignment)

In this passage, Mimi describes her attempt to use the document to defend their use of calculators in middle school, and to question the high school's policy of not allowing

freshmen to use calculators. When she encounters resistance and disinterest from other teachers regarding the document's vision, she is comforted knowing she has the document as an ally and the backing of many educators. The document provides her with the credibility of belonging to a group of "professionals" who "recognize good teaching".

In addition to using the document as a warrant for the use of calculators, Mimi anticipated using the document to defend other instructional practices to parents. For example, she reported already using the document in this way during a recent phone call from the parent of a gifted student. This parent did not understand the value of teachers taking time in mathematics class to have students explain to each other their method for solving a problem.

And that's what I'm working with a couple of parents on who do have bright kids. They don't want to share their knowledge. "My kid figured it out and I don't think it's her job to pull this other student along." That's a seventh grade parent that's calling me today in fact! ... Well, I tell this parent that Communication is one of the standards, too. And to say that that one is not as important as algebra, I don't think is fair. They may not be able to explain it to a slower student in the same way that a teacher can, but to work on those skills is still an opportunity for them. But, they don't see it as an opportunity. It's more like an extra assignment. (Mimi, Sixth Study Group Session)

Again, Mimi uses the document to as a warrant with parents, assuming that it would have some "pull" with them.

Mimi's interest in ways the document could be used as a warrant to parents and others stems in part from her school's recent adoption of a new mathematics curriculum, the Connected Mathematics Project (CMP). Some parents and community members had expressed concerns and skepticism about what they saw as a radically different curriculum. As Mimi had taken on more of an administrative role in her school during the year of the project, addressing these concerns had become one of her primary goals. In

other words, she had come to the study group project already on the lookout for ways the document might be able to support her and her colleagues in their reform efforts.

Brian and Mimi were not the only teachers to view the document as a warrant for their current beliefs or practices. Like Brian, Carla saw the document as giving her permission for certain practices, such as insisting that whole number computation be developed in the elementary grades. "Teaching of whole number operations must be done in the elementary grades. [We] can't do everything in the middle grades. PSSM seems to give us that okay" (Carla, NCTM Homework Assignment). In addition, Carla discussed the possibility of using the document to defend her assigning mathematics homework.

I guess one thing, on page 371 where it says that, "All middle grades and high school students should be expected to spend a substantial amount of time every day working on mathematics outside of class, in activities ranging from typical homework assignments and projects to problem solving in the workplace." Which, you know, it sounds wonderful, in this little fantasy. But, I thought that was pretty bold. I guess if someone ever questions, "Gee, you're giving my child too much homework" you just give them [sic] a copy of this. Tell them, say read it. Nationally, that's what is... (Carla, Eleventh Study Group Session)

Like Mimi, Carla envisioned using the document to defend her practices to parents. Thus, it seems that she, too, assumes that the document will be persuasive to parents, perhaps because it is distributed "nationally".

In summary, several of the teachers saw the document as a warrant for their current beliefs and practices. However, the types of practices they hoped the document could help them defend, and the audiences for whom the defenses were intended, varied. Many of the teachers envisioned using the document's stance on technology to defend the ways in which they used calculators in their mathematics instruction. Others saw the document as a sanction for the incorporation of more communication or more homework.

While most teachers focused on the document's potential to speak to others, some teachers used the document as self-validation. This tendency of teachers to view the document as a warrant or sanction for what they already believed or were doing parallels findings from the R<sup>3</sup>M project (Masingila, Tinto, & Johnson, 1996) that some of the teachers they studied saw the *Standards* as an "after the fact" validation of practices already underway.

Underlying this perspective of the document as a warrant is an assumption that the document comes with considerable authority behind it. This assumption is neither surprising nor inaccurate. The NCTM is the world's largest mathematics education organization, recognized by teachers, administrators, teacher educators, educational researchers, and policymakers as an influential and respected leader in mathematics education. As such, the NCTM's *Standards* documents inherit some of this authority. The teachers recognized this and hoped to capitalize on the document's influence.<sup>2</sup>

This disposition to assume and try to capitalize on the document's authority is also evidenced in another, related view of the document assumed by some teachers, namely that of the document as a *lever for change*.

### **The Document as a Lever for Change**

Closely related to the teachers' notion of the document as a warrant was the perspective, exhibited by several teachers, that the document could be used as a *lever for change*. Both perspectives rely on an assumption that the document brings with it

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<sup>2</sup> What is more provocative than the teachers' inclination to view the document as a warrant is the motivations that might underlie this proclivity. In Chapter 8, I discuss some hypotheses that might explain this tendency.

considerable influence and authority. However, in contrast to viewing the document as a warrant for their *current* practices, teachers who viewed the document as a lever for change saw the document as a tool for brokering for *new* practices in their schools or districts. For example, during a discussion of the Algebra Standard, Dara reacts to the document's recognition of the demands their algebra recommendations place on teachers' content knowledge.

One thing I noticed at the very end though was, I guess when you were talking about kind of purposes of this document, was I thought it really pushed the whole... It made me think about when she [Kayla] mentioned the skills of elementary teachers, because it even focused a little part on the middle school, [that] many middle school teachers don't have the content knowledge they necessarily would be best, or need to teach the algebra. Because they're becoming secondary teachers, they may have the content but not so much of what you need to teach middle school, like the developmental stuff. And then the elementary teachers are just kind of the opposite. They [the Writers] really pushed the issue of professional development. I thought, oh this is a part that should be photocopied and given to my principal!

#### *Laughter*

That's the one part of the chapter I did think that they were really kind of saying that needs to part of it and preaching a little bit for us. And just making a big deal. (Dara, Third Study Group Session)

In Dara's view, the document can serve as an advocate for teachers. But instead of using the document to defend something she already does, she considers asking her principal to read the document with the intention of using it to broker for something new, namely more (and better) professional development.

The group revisited this discussion about using the document as a lever in the next study group session.

Brian: Are you saying if you took this to your principal or to your superintendent and said, "This is what we're looking to do. Look at this. What can you do to help?" It might. I think it's going to take a much

bigger push than just an individual teacher or an individual administrator. It's going to take a school district-wide push or a statewide push or something to make something happen. It's not going to happen until you  
(Inaudible)

Dawn: But, would it help to be able to point to this?

Brian: Yeah, I think it would, but I don't know if it would be enough.

Carla: I was going to say I don't know if principals and superintendents and school-related people would have a problem with this. It's, the first question they would say is, "Where do I get the funding for this?" Because you could always add on days and pay teachers extra to do that, which most of us would gladly do instead of writing a sub [plan]. It's just that, does NCTM get the respect it deserves from government that passes out the pennies to them? Are we to that point? And have they pushed it or...?  
(Fourth Study Group Session)

In this episode, Brian and Carla discuss the potential of the document as a lever for change. Brian considers the feasibility of bringing the document to administrators to make a case for professional development. He is skeptical of how much influence individual teachers, armed with the document, can have in this domain. Carla builds on Brian's comments, stating that the key issue is financial in nature. She wonders aloud whether NCTM really has the authority to influence the government's purse strings.

In addition to envisioning the document as a lever for procuring needed support and resources from administrators, teachers also saw the document as a lever for catalyzing other teachers (almost always elementary school teachers) to make changes to their practice. For example, in discussing the goals for developing Big Ideas files for each standard, Carla suggested that the files could be used to get elementary teachers on board.

And I mean, I'm guessing, and I'm only basing it on the staff I work with, that because elementary has so many different standards to worry about, all subject areas, that they would be less apt to spend time unless that was really their subject. And that having these [the Big Ideas] done would be something that you could encourage them to become familiar and maybe even spur them on to other things. Because we have several of ours, and

I've tried to encourage someone to take a look at them, but nobody else is interested right now. (Carla, Twelfth Study Group Session)

Unlike the previous examples, in which teachers considered using the document to lobby for changes for themselves (namely, more and different types of professional development), in this example Carla reflects on the potential of the document, through the vehicle of the Big Ideas, to “spur” elementary teachers to improve their teaching.

Brian also considered the document as a lever with catalyzing elementary school teachers.

Brian: So, that was kind of nice to be able to go on and actually read some of that stuff [the Standards for Grades 3-5] about what would be a high expectation of them [elementary grades]. I think that our district is feeling a lot more of the pressure to push the elementary school more, so it's nice to have a little more evidence of that. ... I would think though that it would certainly be supportive of issues that would come to change and I plan to have a meeting with our assistant superintendent and tell him what we're doing and provide him with additional ammunition on this...

Dawn: Right

Brian: ...to push the elementary schools. (Interview, May 2, 2001)

Recognizing that his district is planning to raise expectations of its elementary school teachers, Brian sees the document in terms of its potential to be used as a lever, or “ammunition”, for compelling those teachers to respond. Similar notions of the document’s potential as a lever for change were explored by Tim:

I also hope to obtain enough evidence from these sources to help back up my claims about how students in our building should be educated. As it stands now, I have had a difficult time convincing the other math teachers in my district about the things they should and should NOT be doing in their classrooms. Having a respected source to refer back to should help me greatly. ... I intend to use the background I acquire from this study to aid me in my quest to reform the attitudes and stale mindsets of several teachers in our building and the lower levels. I am tired of taking half of the school year training my seventh graders to be able to be strong mathematical thinkers in the fashion I expect of them. I will be

disappointed if I am unable to convince people of the changes we should make due to constraints placed upon us by the government, school policy (that's the way it's always been), or uninformed teachers. (Tim, Second Journal Entry)

In this passage, images of the document as a warrant and as a lever for change are intertwined. Tim foresees using the document to support his current views about how and what students should be taught (warrant); he also sees the document as a shining sword in his “quest to reform the attitudes and stale mindsets of several teachers” (lever for change). The document is a respected authority that will “back” him (warrant), and it is a tool for convincing other people to change (lever).

Underlying these examples is a realization by many of the teachers in the study group that much of their work in middle school depends on what teachers in the grades before them do or do not accomplish with students. The document’s vision for middle school mathematics had been developed on an assumption that certain mathematical understandings would be developed in the earlier grades. Thus, teachers recognized that their ability to work toward the document’s recommendations was constrained by what happened in elementary school. For example, they were struck by the document’s strong stance that whole number operations should be completely developed by the end of fifth grade, so that middle grades teachers could focus on developing rational number concepts and operations. Although many of the teachers agreed with this stance, they recognized that it was not a reality and thus they would have to make decisions about how to address their students’ deficiencies with whole numbers. Cognizant of these challenges, teachers viewed the document as a lever for ensuring that elementary school teachers did their part.



In summary, many teachers also viewed the document as a potential lever for brokering for desired changes. In particular, teachers envisioned using the document with administrators to lobby for more resources, and with elementary teachers to spur them to improve their teaching. On the surface, using the document as a lever to make changes that are (purportedly) aligned with the document might seem indistinguishable from using the document as warrant. Indeed, I struggled for a long time with whether or not to make this distinction. In the end, I decided it was important to differentiate them, concluding that the key distinction is in the desired end product. For the warrant perspective, the desired product is protection, defense, and maintenance of one's current beliefs and practices.<sup>3</sup> For the lever perspective, the desired product is change, hopefully leading to improvement. Thinking of the document as a warrant seemed the more typical and perhaps less interesting viewpoint. This view might just encourage teachers to maintain the status quo, to shirk improvement by using (and possibly twisting) the document to defend their current practices, regardless of their nature or alignment with the document's recommendations.

### **The Document as a Tool for Teacher Learning**

In contrast to thinking of the document as a warrant or a lever for change, some teachers envisioned the document as a tool for their own continued learning. For example, in preparing for our NCTM presentation, Joyce reflected on her study of the document and wrote:

I think that the document will have a different impact on each reader depending upon their particular situation and needs. Reading it again next

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<sup>3</sup> This is not necessarily undesirable, especially if one is already a highly effective teacher.

year will probably affect me in different ways than it has this past year. Even as I reviewed sections of it in preparation for our presentation, I found new understanding (and questions) that I did not find the first time I read it. I view it as a learning tool that can be a continual resource for teachers who are interested in growing professionally. I hope that we can encourage other teachers to invest their time in its reading. What everyone will learn will vary, but I think we can guarantee that it will be a worthwhile learning experience for anyone who takes advantage of the opportunity. (Joyce, NCTM Homework Assignment)

For Joyce, the document is a source of learning for her and for other teachers. What is interesting about her perspective, and that shared by other teachers, is that they view themselves as learning *from* the document, not *about* the document. That is, in addition to learning about the document's recommendations and perspectives, teachers saw themselves learning, from the document, ideas about mathematics teaching and learning and about their own practice. This view of the document as a tool for learning about one's teaching resurfaced during their study group conversations. For example, during the beginning of the second study group session, teachers were sharing their overall reactions to their first readings from the document.

Monique: I just wanted to comment. It seems like it is common sense and nothing was like so technical that you read something and were like "huh?" I mean, it seemed like you were kind of reconfirming what you already do or what you already thought...

Kayla: I found myself almost reading it too fast because of that, and not thinking about it as hard as I should. Because I read through it and I thought, "Oh yeah, oh yeah, I knew that. Oh yeah, I thought about that." And then when I went back and read it again I stopped to think about it and talked to another teacher in my building about it. I don't necessarily do what I thought I was doing. I don't know how to say it. The first time I read it through I thought, "Oh yeah, this isn't [inaudible]." And then when I went back through it again and eventually, this is about my fifth time reading it since I got it last April I thought there was a lot more here for me to think about, especially in the Principles those are the ones, you know like open-ended assessment. Things where I thought, "Oh yeah, I'm doing that." But I had to stop and reconsider... (Second Study Group Session)

In this passage we see two very different perspectives on the document. Monique finds that the document's recommendations align with what she already thinks and does. Kayla admits to initially having the same reaction, but in reading the document more carefully, and discussing it with a colleague in her building, she finds the document leading her to think about her practice more carefully. In doing so, she realizes that "I don't necessarily do what I thought I was doing". Thus, studying the document helps Kayla become more aware of and explicit about her beliefs and practice, a key component to dissonance.

Monique's reaction surprised me, as she and Joyce were using the Saxon mathematics curriculum (a curriculum not at all aligned with the vision put forth by the NCTM). Interestingly, by the end of the study group, Monique held a different perspective. " And the thing that's frustrating at least for myself, and I don't know about Joyce, is we teach from that Saxon book. ... We do kind of intersperse what we do, but still we never get to any of this stuff. There is no time for exploration or anything like that because it's such a cut and dry thing. So, how do you buck your entire district and say, read this [the document]! This is what it should be. I don't want a calculus book or a geometry book. I want something that presents everything all at the same time" (Fourteenth Study Group Session).

In his journal, Brian reported having similar reactions to the document.

Perhaps that is why I am enjoying the document so much. It continues to reinforce my thinking while it helps me look at ways to rethink my practice to achieve the ambitious goals. For example, I read the third paragraph on p.14 several times as I thought about teaching in [name of school district]. I realized how fortunate I am to teach in a community with unbelievable resources. Yet, there is so little we do in terms of using parent mentors, developing tutoring groups, and communicating with our community. My first impression of the paragraph focused on the "special needs" student. But as I read it over, I realized how relevant it should be

for me in the land of "gifted" students. The timing of this is serendipitous, as we are currently developing web pages in our building. I will try to think of ways to use this to further involve our community resources. (Brian, Third Journal Entry)

In this clip, Brian refers to the document helping him to "rethink my practice". In particular, he talks about reading and reflecting on a particular passage in the document in light of his teaching. In this passage, the Writers posit that, "equity requires resources and support for all classrooms and students" (NCTM, 2000, p. 14). Brian comes to realize that he is not taking advantage of the wealth of resources available to him in his community, and vows to do a better job of this in the near future. Thus, again we see signs of dissonance – Brian is becoming more explicit about his practice and identifying pieces with which he is dissatisfied. Lara also writes how the document was helping her analyze her practice and question her curriculum. "The other thing that I like about this document is that (again with some of the examples and the actual text) that it is helping me confirm or question rationales of what I am teaching. As in why specific topics - why this way?" (Lara, Third Journal Entry) Mimi viewed the six guiding principles put forth in the document as a potential assessment tool for teachers.

The principles provide an evaluation tool for teachers. As teachers reflect on their teaching and their students, they should be cognizant of these principles. They should continually be assessing their understanding of these principles, and rich discussion can flow from such reflection (Mimi, Third Journal Entry)

Thus, one way in which teachers envisioned the document as a tool for their learning was in its potential as an instrument for analyzing their practice and becoming more explicit about their beliefs and values.

Other teachers saw the document serving as a tool for teacher learning through its inclusion of controversial recommendations and non-traditional perspectives on school

mathematics. For example, as the teachers discussed the Algebra Standard, they took up a conversation of what “algebra” should be for middle school, and what parents and students thought algebra should be. Kayla remarked:

And that's why I thought reading this, it shakes up what algebra is. If algebra at the middle school isn't just x, y, and equations, then what is it and what do we need to be doing? I thought this was really pushing at us to think about algebra differently for sixth, seventh, and eighth graders. (Kayla, Third Study Group Session)

Here Kayla characterizes the document's stance on algebra as provocative, as “shaking up” what algebra is. By taking a more radical stance, she feels that the document is “pushing at” teachers to think differently about algebra. Another way to interpret this is that the document is causing her to experience *dissonance*. Kayla is noticing an incongruity between her ideas about algebra and those put forth in the document. This is causing her some discomfort or uncertainty, and so she begins to reexamine her own stance on algebra in light of the document's stance.

This notion of the document pushing people's thinking resurfaces later in the teachers' discussion of the Algebra Standard. The passage below opens with Brian inquiring about the Writers' intentions behind providing an unusually lengthy discussion of the various meanings and uses of variable in the document.

Brian: It just felt much more explicit than some of the other stuff I read in the chapter. It takes up quite a bit of the chapter. I think most of the stuff is just a higher aspect of... [*inaudible*] ... When I read it I also thought it was *trying to push people outside of their little box* [italics added], because most people would just think of, you know, a variable stands for a number that you find the answer for. And this was *a way to push people a little bit further than those people* [italics added].

Kayla: I think *it's even more staggering* [italics added] if you have a chance to go to the 3-5 [grade band] and look at how they talk about the use of variable and starting it in grades three through five and looking at the different ways variables are used in a situation. I think that's, it would

make things so much smoother, flow better, but I don't know that... it's the same [issue], if all elementary teachers have the math background to be able to see that. It's very difficult, to put it bluntly.

Janelle: Maybe that's part of this too, is that this document is a teaching tool as well. It's not just setting up standards [for us], but teaching [us]. Because I really put myself in a learner situation and I actually learned a number of things that I didn't know before, that I hadn't thought about in this way. So, I kind of like that, I absorb it. (Third Study Group Session)

Brian frames the document as a provocateur, striving to “push people outside of their little box” in order to broaden their understanding of variable to meanings other than variable as placeholder or missing value. Kayla follows up on this idea by characterizing the document’s recommendations for algebra in grades three through five as “staggering”, and expressing concern about elementary teachers’ capability to understand the algebraic ideas in their grade band. Again, the concept of dissonance seems appropriate here. Both Brian and Kayla recognize that the document’s vision of algebra for the middle grades (or the elementary grades) is quite different from the vision held by most teachers. Brian concludes that the document was purposeful about this and intended to really challenge and deepen teachers’ thinking about algebra. Janelle builds on this discussion by suggesting that perhaps the document has been designed to do much more than just disseminate standards – perhaps it has been designed to serve as a tool for teachers’ learning.

In summary, several teachers viewed the document as a tool for their own continued learning. In particular, by reflecting on the document’s recommendations, teachers reported becoming more aware of and explicit about their own beliefs and practices. They began to recognize what it is they are really doing in their classroom, and which areas are in need of revision. Related to this, some teachers saw the document

serving as a learning tool in that particular passages had been purposefully written to provoke readers, to push their thinking. Most interestingly, across these examples, teachers are seeing the document as something they can not only learn *about*, but also *from*. Thus, they see the document as *generative*, in that it can be used to stimulate new learning. This notion of the document being generative also emerges in the next section, in which I discuss teachers' views of the document as a *springboard for discussions*.

### **The Document as a *Springboard for Discussions***

Yet another view of the document expressed by some teachers was that of the document as a springboard for rich conversations around mathematics education issues. This perspective is actually put forth as one of the purposes of the document in Chapter 1: "This document is intended to... stimulate ideas and ongoing conversations at the national, provincial or state, and local levels about how best to help students gain a deep understanding of important mathematics" (NCTM, 2000, p. 6). This is an interesting goal to put forth, for it seems to represent a quite different vision of the document than as a set of recommendations and a vision to work toward. It communicates a view that the document is not a set of clear mandates to be taken up directly, but a set of interesting ideas that should catalyze conversations about what the vision of school mathematics should be. Brian was intrigued by this notion.

Well, anyway, it was kind of interesting for me to read that second paragraph on page six because I had not thought about, I mean I've read this before, but I completely skipped the first chapter because it was long. So, to have actually be forced to read it I could see that. But that second paragraph—to say that the role of this whole document is to initiate discussion in the arena of a lot of controversy... So, it's not like they're taking a stand one way or another necessarily, but trying to pull out some

ideas and get people thinking, which I think that's perhaps not always interpreted [*inaudible*]. (Brian, Second Study Group Session)

Although the other teachers did not comment on this passage directly, they did express similar ideas about the document's potential as a catalyst for conversations. For example, Kayla reflected this viewpoint during a discussion during the third study group session. Teachers in Kayla's school had been studying the document (outside of the context of this project) and using it to guide their practice.

Kayla: We've found this document has been so helpful this year because it took away from, "Well, I think...". "Oh, well you're wrong and this is what I think" and you know, all that. This is so much easier to have a conversation around because it took the I's and me's and you's and them's out of it and we could just talk about what this means in our district and what this means for our kids. So, I found it, we have found it very helpful in changing conversations from finger pointing, at least for now.

Brian: Are you talking about between buildings?

Kayla: Yes, and K-12, too. (Third Study Group Session)

Kayla sees the document as something around which teachers in her building have been able to gather and have productive conversations. Underlying her comments is the view that the document's recommendations and ideas are not ready-made. Rather, there is work to be done by teachers and other interested parties in determining how the document's recommendations and ideas make sense in their local contexts, and this can occur through conversations stimulated by the document. In preparing for our NCTM presentation, Callie expressed similar notions.

For the most part all sections of this book appear to be very thought out, the principles, standards and visions. But it wasn't just the reading that helped me to see and understand better. Without groups of teachers in the same grade area to discuss their interpretations, problems, and successes as we read through the book I don't think I would have gotten the most value out of this activity. It would have been the same the other way with just the discussion and not reading the document. The book supplied



thoughts and ideas to share and discuss further and to talk about realities and dreams in relation to the visions of the National Council of Mathematics [sic] document. (Callie, NCTM Homework Assignment)

In this passage, Callie describes the document as providing the fodder (“thoughts and ideas to share and discuss further”) for teachers’ discussions, and that these discussions supported her learning. In fact, it seems Callie is arguing that studying the document in isolation would not be sufficient, but that the conversations it generates are a necessary component.

Mimi also saw the document – the Principles, in particular – as a springboard for interesting discussions.

So far, I need to look at the document from two different stances. I need to look at the principles and the standards as two separate, but united pieces. Within each standard, the principles need to be applied. The principles I find to be more compelling, more thought-provoking, and more easily lending itself to discussion. The standards I find are guides to material that needs to be covered. ... Each principle could be a discussion topic for an entire evening. I find them open to interpretation, and expressing high ideals. It would be good for teachers in all subject areas to discuss these principles, and perhaps even to review them throughout each year. (Mimi, Third Journal Entry)

In this passage, Mimi pinpoints the Principles from Chapter 2 as especially generative of discussions. In fact, she feels that the discussions they can stimulate are important enough to encourage teachers in *all* subject areas to study and discuss them. Underlying Mimi’s comments is a view that the document’s recommendations and messages are not clear-cut mandates that are to be blindly implemented. Rather, Mimi sees the Principles as “open to interpretation” and worthy for teachers to pursue through discussion. She expressed these ideas again during the tenth study group session.

And I’m hearing some things, one of the teachers was saying, all the groups, all year have to be mixed-ability grouping all of the time. And I’m hearing from parents that this isn’t right. And then when I went to see,

visit, I saw ability grouping at one school and I saw no grouping at another school.<sup>4</sup> And so, I don't think that makes ability grouping necessarily always right all the time. And I think that's led me to think that this [*points to the document*] is a guide that takes it out of the administration committee, or takes it out of the curriculum director's committee and gives us a neutral starting point for discussion... (Mimi, Tenth Study Group Session)

Mimi sees the document as a “neutral starting point for discussion”, not a prescription for mathematics teaching and learning. In fact, she is so convinced of the value of teachers engaging in discussions around the document that she plans to use the document with teachers in her building next year.

I would like to use the PSSM document as a basis for some of our discussions this fall. It is going to be helpful to me to have the summaries for the 3-5 grade level information on the standards. I think some of the process standards would be a good place to start, as the teachers could see development across the grades, and perhaps they wouldn't be so defensive as they can be over "number." (Mimi, Seventh Journal Entry)

In this passage, Mimi reiterates a theme first voiced by Kayla, namely the notion that the document can serve as a neutral or safe place around which teachers can come to interact in productive ways.

In this section, I presented results from my analysis of the ways in which teachers saw themselves using the document. This analysis reveals that teachers are capable of viewing the document in multiple ways – as a warrant for their current beliefs or practices, as a lever for effecting change, as a tool for their own learning, and as a springboard into rich discussions of important issues in mathematics education.<sup>5</sup>

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<sup>4</sup> Mimi is referring to visits she had made to other teachers' classrooms. In the budget for the grant, I had included funding for teachers to have release time (through reimbursement for substitutes) so that they could observe their partner's classroom, as well as the classrooms of other teachers in the study group. Several teachers took advantage of this opportunity and shared their observations and reactions during the study group discussions.

Moreover, this analysis indicates that individual teachers are capable of assuming more than one perspective or way of viewing the document. In Chapter 3, I made an argument that understanding how teachers view the document is important in that it will influence how they approach their study of the document and what conclusions they form about the document's recommendations. In the next three chapters, I present case studies of Brian, Janelle, and Joyce. In these cases, I will explore the relationships between the ways in which these teachers viewed the document and the ideas they developed about the document's messages.

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<sup>5</sup> Not surprisingly, teachers also viewed the document as a *curriculum map* (a tool for analyzing and revising one's mathematics curriculum). This viewpoint will be elaborated in Chapter 7.

## CHAPTER 5

### THE CASE OF BRIAN

In general, I agree with the messages of the document, and embrace them enthusiastically. However, I find that “embracing” and “practicing” are two different things. Perhaps that is why I am enjoying the document so much. It continues to reinforce my thinking while it helps me look at ways to rethink my practice to achieve the ambitious goals. (Brian, Third Journal Entry)

This chapter presents an account of Brian’s participation in, and learning from, the study group. Brian’s story is of one of a confident, experienced middle school mathematics teacher, who is teaching from, and well trained in, the *Connected Mathematics Project* curriculum. Brian’s story is the story of a teacher who has already been exposed to and developed some awareness of *Principles and Standards* through reading the previous *Standards* documents and attending professional development. Brian’s story is one of an expert teacher who is ready to be challenged and pushed to the next level. By exploring Brian’s case, I can explore the potential of the document to stimulate and be meaningful to experienced mathematics teachers who are implementing a *Standards*-based curriculum and who are already very familiar with the document’s vision and recommendations for mathematics education.

The chapter begins by describing relevant background information about Brian — his teaching experience, school context and curriculum, motivation for participating in the study group, and incoming awareness of and ideas about the NCTM *Standards*. Next, the key ideas that Brian developed about the document are identified and elaborated. The

chapter concludes with a discussion of what impact participating in the study group had on Brian's beliefs, knowledge, and priorities for his classroom practice.

### **Background Information**

Brian had been teaching for 21 years, with the last eleven years spent teaching middle school mathematics. He holds bachelor's degrees in music education and music performance, and was certified for K-12 music and grades 6-8 all subjects. He had completed some undergraduate work in mathematics and computer science, and was working on a graduate degree in mathematics education at a local university. Despite the lack of a formal degree in mathematics, Brian demonstrated a deep understanding of and appreciation for mathematics during the study group sessions. He exhibited confidence in his teaching and in his interactions in the study group.

At the time of the study, Brian was teaching sixth and seventh grade mathematics in a public middle school in a very affluent suburban district in mid-Michigan, and was chair of the school's mathematics department. The school had adopted the *Connected Mathematics Project* (CMP) curriculum, an NSF-funded "standards-based" mathematics curriculum for grades 6-8, several years ago. Brian reported having three goals for improving his teaching: 1.) find ways to be more efficient with the limited time he had for mathematics instruction; 2.) help his students become better able to communicate their thinking; and 3.) become better able to differentiate his mathematics instruction to meet the needs of a heterogeneous group of students (Application, Question 3b). Maximizing his efficiency in the classroom was especially important to Brian, as his class periods were only 45 minutes long.

In his application to the study group, Brian reported that he had read the previous *Standards* and had “skimmed” the most recent document. “I have a good sense of the Principles and Standards from school in-services, conferences (NCTM and MCTM<sup>1</sup>), and department meetings and planning in our school. As a member of NCTM and MCTM, I continue to stay abreast of the standards through their periodicals and programs” (Application, Question 2). This idea of keeping up with current trends in mathematics education resurfaced in his description of his goals for participating in the study group.

I am keenly interested in participating in the (MS)<sup>2</sup> project. Issues of excellence in math education are going to be central in the push toward improving education in general. I like to stay current and knowledgeable so I can continue to improve and provide the best I can for students. Hopefully, I will walk away from this project with a deeper understanding of the standards, and practical ways to implement them on a regular basis. (Application, Question 4)

Staying aware of current trends helped Brian feel more confident, both in his instruction and in his interactions with parents, administrators, and other teachers. In particular, Brian expressed an interest in developing a better understanding of how to address computational algorithms and how to meet the mathematical needs of all his students. In discussing his motivation for studying the document, Brian wrote, “I will be thrilled if I come away with some useable ideas to apply in my teaching re: computation and diverse learners. If this is not possible, I would be happy to at least come away with a better understanding of what is happening in the field with these two issues, and maybe have some sources for further development” (Second Journal Entry).

Brian entered the project familiar with many aspects of the NCTM’s vision of school mathematics. For example, in describing what he would expect to see in a middle

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<sup>1</sup> Michigan Council of Teachers of Mathematics

school mathematics classroom that was aligned with the *Standards*, Brian highlighted that the instruction would focus on helping students develop an understanding of “big” mathematical ideas through hands-on exploration and problem solving, rather than developing discrete skills through repeated practice.

As an example, rather than presenting the formula for the surface area of a rectangular prism, students might engage in wrapping unit cubes with grid paper. Rather than practicing the given formula for surface area during the lesson, students might work collectively to develop alternative strategies for determining surface area. Rather than take a test where students calculated surface area of given arbitrary dimensions, students might be asked to work in groups to design a rectangular package for a given volume using the least amount of paper. (First Journal Entry)

Although Brian noted that the NCTM called for students to develop conceptual understanding of key mathematical ideas, he also recognized that the *Standards* still included the development of students’ computational skills as an important learning goal. He described the teacher’s role in a *Standards*-based classroom as more of a facilitator of student discussions than a lecturer or “teller”. Finally, he noted that *Standards*-based instruction would incorporate a variety of formal and informal assessments in order to gain a complete picture of students’ understanding.

### **What Ideas Did Brian Develop about *Principles and Standards*?**

In this section, I discuss some of the key ideas that Brian developed through his study of the document and participation in the study group. I begin by describing Brian’s overall impressions of the document and the ways in which he came to view the document and its purposes. Next, I trace Brian’s ideas about a central theme that arose from the document and that became salient to Brian, namely the role of technology in

instruction. Finally, the section concludes with a summary of the impact the study group had on Brian.

### **Overall Impressions**

Overall, Brian was very pleased with *Principles and Standards*. From the beginning, he found the document well written, reader-friendly, and stimulating.

First of all, I love the set up of the book... I love the language. It's very concise, it's easy to read, brisk, a lot of wisdom... Obviously they cut and cut and cut and cut. And so, I really enjoyed it because it seemed like everything I was reading was really important, makes sense, and they did use the word "rich" too often. (Second Study Group Session)

Brian maintained these positive impressions of the document throughout the project. For example, in his third journal entry, he wrote, "So far, I am very comfortable with the document. These are some things I especially like: The chapter structure is simple and meaningful. The concise but undaunting [sic] language is easier to read than I might have suspected..." And by the end of the project, in preparation for a presentation we would be giving at an NCTM annual meeting, Brian reported that important impressions about the document that he wished to share with our audience were "[The document is] well-written, easy to understand, intuitively organized... [and] thought-provoking" (NCTM Homework Assignment).

Brian found himself agreeing with and feeling supported by many of the document's messages. For example, reconsider the following passage from Brian's third journal entry, which opened this chapter.

In general, I agree with the messages of the document, and embrace them enthusiastically. However, I find that "embracing" and "practicing" are two different things. Perhaps that is why I am enjoying the document so much. It continues to reinforce my thinking while it helps me look at ways



to rethink my practice to achieve the ambitious goals. (Third Journal Entry)

Brian notes that many of the document's claims are aligned with his current beliefs and priorities; he and the document are, for the most part, in agreement. Consequently, he is able to view the document as "reinforcing" (his words) or validating his thinking. In this way, reading the document is helping Brian become more explicit about his current beliefs and values, an important component of the *dissonance* stage. However, simultaneously Brian notes that the document is encouraging him to "rethink my practice" to be more aligned with the document. This suggests some dissatisfaction with his teaching, and recognition that the document provides alternatives for consideration, another important component of dissonance. Thus, the document is also serving as a catalyst for analyzing and improving his practice.

This notion of the document reinforcing what he already thinks reemerges later in the same journal entry, when he discusses his reactions to the overview of the Algebra Standard presented in Chapter 3.

The general standard for algebra (p. 37-40) was, for me, the most interesting section I've read so far. It *hits home* [italics added] because I deal with "introductory algebra" as a major focus of my curriculum... In particular, the quote from p.39, par 4 "In general, if students engage extensively [in symbolic manipulation before they develop a solid conceptual foundation for their work, they will be unable to do more than mechanical manipulations]" *reinforced my belief* [italics added] in teaching algebra. (Third Journal Entry)

In this passage, Brian repeatedly mentions how a particular statement in the document coincides with his own beliefs about teaching algebra in middle school, and thus serves to confirm and bolster his stance. The document's claims fit with his own experiences and thus "ring true" to him. As a result, he feels empowered to continue his current approach

to teaching algebra. By reminding him of what he believes, reading the document is again helping Brian become more explicit about his own beliefs, a key step in the dissonance stage. Brian expresses similar views in a discussion of Chapter 8 during the tenth study group session.

Well, the comment I liked the best was on the very last page, the conclusion. It's *something that I see quite a lot at our school* [italics added] on the teachers of every subject, not just math, which is "any vision of school mathematics teaching and learning needs ongoing examination" [p. 380]. *I see it all the time in our building* [italics added] in science, and language arts, and math, too. It's like well, we're going to pick our textbook, and that's it. Until the next time we pick our textbook, that's all we have to worry about. And I feel there has to be an investment in the fact that teaching is not just going in and teaching your lessons. There has to be a certain amount of your day and your energy, every year, donated or given or reserved for curriculum development across the board. (Tenth Study Group Session)

Again, Brian finds that claims made in the document match his perspective on curriculum, and his experiences with teachers in his own building. As a result, he likes and agrees with the document's messages, and feels validated by them.

### **Ways of Viewing the Document**

Brian's comments during the study group sessions and in his journal entries indicate that he envisioned using the document as a lever for change, as a warrant, and as a tool for teacher learning. I elaborate on each of these in turn.

Brian considered two ways that the document could be used as a lever to effect change. The first was to use it as a brokering tool with administrators, in order to make a case for some desired change.

Brian: Are you saying if you took this to your principal or to your superintendent and said, "This is what we're looking to do. Look at this. What can you do to help?" It might. I think it's going to take a much

bigger push than just an individual teacher or an individual administrator. It's going to take a school district-wide push or a statewide push or something to make something happen. It's not going to happen until you (Inaudible)

Dawn: But, would it help to be able to point to this?

Brian: Yeah, I think it would, but I don't know if it would be enough.  
(Fourth Study Group Session)

In this clip, Brian considers the possibility of using the document with his principal to make a case for the need for more professional development opportunities in his district. Although he predicts that this might be somewhat productive, he realizes that the document might not be a strong enough lever to produce the changes he desires. Thus, he does not seem to overestimate the authority that NCTM conveys with principals and others.

In addition to using the document to lobby for changes he wanted for himself, Brian also saw himself using the document as a lever for influencing the elementary school teachers in his district.

Brian: So, that was kind of nice to be able to go on and actually read some of that stuff [the Standards for Grades 3-5] about what would be a high expectation of them [elementary grades]. I think that our district is feeling a lot more of the pressure to push the elementary school more, so it's nice to have a little more evidence of that. ... I would think though that it would certainly be supportive of issues that would come to change and I plan to have a meeting with our assistant superintendent and tell him what we're doing and provide him with additional ammunition on this...

Dawn: Right

Brian: ...to push the elementary schools. (Interview, May 2, 2001)

In this passage, Brian proposes using the document to compel the elementary school teachers to improve their teaching.

Brian also recognized the document's potential for serving as a warrant for current practices or beliefs. For example, consider his reactions to the Algebra Standard.

I face opposition on this stance every year from parents who think algebra means solving for x. They wonder why I make the students make so many graphs and tables before we even discuss symbolic manipulation. I also face opposition from other teachers, especially many high school teachers, who think symbolic manipulation is the ultimate goal of an algebra class... How did the document affect me as I read this section? It *encouraged me to continue* [italics added] my "functional" approach to algebra by *reminding me of what I believe* [italics added] but often get tired of defending. It *validated my thinking* [italics added] and supported what the CMP series is doing. (Brian, Third Journal Entry)

Brian feels that his current approach to algebra instruction is validated by the document and thus sees the document as "encouraging him to continue". In other words, Brian sees the document's stance on algebra as justifying or defending his approach. This notion of the document as a warrant reemerges during a discussion of the Number and Operations standard.

Brian: Ok. I'll risk it, I'll say it. I liked on p. 32, "When teachers are working with students on developing computational algorithms, the calculator should be set aside."

Janelle: I agree with that, too.

Dawn: Where is that, Brian?

Brian: It's on page 32, at the very bottom.

Dawn: At the bottom?

Brian: Yeah, the last sentence. I guess I saw it as *giving permission* [italics added] to do some back to basics type of instruction, or what would be seen as back to basics by the parents. I know that there's always a sigh of relief at open house when I say, "And some of the times this year your kids will not be allowed to use calculators. Please look out for that and don't let them." "Oh, yeah," they'll say. I'm sure they...[inaudible] too, but, I guess it's reinforcing, or reassuring to know that they're going to have that every year. (Fifth Study Group Session)

Again, Brian envisions the document as a way of justifying how he already uses (or does not use) calculators in his classroom. In both of these instances, Brian is conceiving of the document as a warrant for himself, not for others.

Finally, Brian also expressed ideas about how the document could be seen as a tool for teachers' learning. For example, in the passage below, Brian sees the document as striving to push people's thinking "outside the box" so that they extend their understanding of the many meanings of variable.

It just felt much more explicit than some of the other stuff I read in the chapter. It takes up quite a bit of the chapter. I think most of the stuff is just a higher aspect of... [inaudible] ... When I read it I also thought it was *trying to push people outside of their little box* [italics added], because most people would just think of, you know, a variable stands for a number that you find the answer for. And this was *a way to push people a little bit further than those people* [italics added]. (Brian, Third Study Group Session)

Brian revisited this notion of the document serving as an instrument for teacher learning. The teachers had been discussing the content knowledge elementary school teachers would need in order to work toward the vision put forth in the document. The passage opens with Janelle arguing that the elementary school teachers are capable of learning the necessary knowledge. In doing so, she touches on the notion of these teachers learning from the document.

Janelle: I just have one other thought. I think that on the topic of, you say the elementary teacher with not as much math background. I think all of this is learnable, and I don't see that that should ever stand in their way. I think it's *all* learnable. I don't think you have to be a math major to, to make yourself knowledgeable. ... So, I, I think, you know *if you can find the same page* [italics added] [referring to the document] and give the time to share that, and I think all the knowledge can be had and I don't think it should ever be an excuse that so and so doesn't have the background, therefore...

Brian: Well, that would be an interesting study...

Dawn: Yes, it would.

Brian: ...to take this document and give them off-level... So, like bring in elementary teachers and show them the high school pages and say, "Can you do this? Show us how."

Edgar: But then the question becomes how could you give them the opportunity to pick up that background.

Brian: Right, because if this is going to be a very useful document, you are going to have to be able to hook up with those people who, we know they're out there, where they're not good teachers, or they have a physics major but they're teaching Calculus because they had to fill in for somebody. And so, how are we going to be able to get those teachers to pick up the knowledge that they need? Well, I think it's well enough that we can start with this [the document], maybe making more references and resources available, make it easy to for people to have the book... (Third Study Group Session)

In this clip, Brian builds on Janelle's idea of using the document as a way to develop elementary school teachers' content knowledge. He feels that the document would be a good starting place for them, but points out the need for additional references and resources. Thus, in both of these examples, Brian views the document as something around which teachers can come together and deepen their content knowledge.

In the next section, I present discussion and analysis of a key issue that became central to Brian as he studied the document and participated in the study group – the role of technology in mathematics teaching. This issue has its roots in the messages and recommendations put forth in the document. Through discussion of Brian's reactions to and developing ideas about this issue, I aim to characterize Brian's experience in the project, and to trace its impact on his beliefs, priorities, and classroom practice. This discussion will also continue to highlight how Brian's study of the document and participation in the study group discussions helped him to move through each of the four

stages of professional development – dissonance, synthesis, experimentation, and integration.

### **The Role of Technology in Mathematics Teaching**

One of the most important themes that emerged for Brian as he studied the document and participated in the study group was the role that technology could, and should, play in school mathematics instruction. Analyses of Brian's application to the project, his journal entries, and his contributions to the study group discussions suggest that technology was not initially a salient issue for Brian. For example, in describing his personal goals for participating in the study group, he made no mention of a desire to better understand what role technology should play in mathematics teaching (Application, and Second Journal Entry). Moreover, Brian's first few journal entries suggest that he does not consider the use of technology as an important recommendation put forth in the document, despite the document's claim in the Technology Principle that "technology is *essential* [italics added] in teaching and learning mathematics" (NCTM 2000, p. 24). For example, in his early portrayal of *Standards*-based instruction in a middle school mathematics classroom, Brian makes only one brief reference to technology, citing the need to occasionally put calculators aside so that students could review their computational skills.

In terms of "skill review," this is an issue I continue to wrestle with. In [our school district], we have recently been pressed with the goal of improving "non-calculator" computation. Students do seem to forget the basic algorithms they have learned if they are not reviewed regularly, especially low-level students... With computation as a continued goal of the Standards, I would have to assume an exemplary classroom would set aside some time each week for computation review. (First Journal Entry)

Later, when responding to the question, “What would you say are [the document’s] main messages and recommendations?” in his third journal entry, Brian again made no mention of the document’s stance on technology.

Despite this inattention to the role of technology in his statements of personal goals and in his early descriptions of the document, Brian reported being aware of and occasionally experimenting with several instructional technologies, such as graphing calculators, spreadsheets, and Geometer’s Sketchpad. However, at the beginning of the project, he seemed skeptical of the value of technology, tending to point out how much effort it requires on the part of teachers in order to implement well rather than the benefits it affords students. For example, consider the following exchange that took place as early as the second study group session.

Monique: Because our high school has it [Geometer’s Sketchpad] and are now proposing that it begin at the middle school, you know. And this proposal, we don’t even know... I mean, let’s see what works.

Brian: I think with middle school students you have to be pretty aware of the curriculum to whatever works best with your structure...

Monique: We do or they do?

Brian: The teacher should do that. I taught MASCOT with the Geometer’s Sketchpad and *we struggled* [italics added] with how do you make this accessible to kids and yet somehow structure it in a way that they could get something out of it...

Monique: So, there’s a lot of fun and...

Brian: You really do need to know the program pretty well before you plan lessons on it and have some idea of what you want to accomplish. Otherwise, you’re just going to have kids playing with the stuff. (Second Study Group Session)

In this passage, Brian warns Monique of several demands that implementing technological tools places on teachers: teachers must have a good understanding of their



mathematics curriculum, must be clear about their goals for using the technology, and must think carefully about how to structure instructional activities so that the students are able to use the technology in a way that supports their learning. One of Brian's greatest concerns about using technology to teach mathematics was the time demand he felt it placed on him. Consider the passage below, in which Brian reflects on the session we spent exploring the document's electronic examples on the Internet.

I will think about your questions to my journal entry and respond soon. As for the computer session, I enjoyed playing with the examples. (I had "saved" doing some of them, knowing we would be going to the computer lab with our group.) The next step would be to explore how to use the e-examples in a class setting. I'm always concerned about keeping students focused, and therefore I probably over structure the environment (don't want anyone wandering off on the internet, or distracted by other examples, etc.). I guess my first reaction is to smother the kids with worksheets to guide them through their explorations and record their work. But is that the best way to use them? As you know, I work with a skimpy 45-minute class period. I'm always trying to compact busy-work and trim away everything but the essentials of my lessons. What are some ways we can do this in the computer lab? When does using an e-example cease to be productive and begin to become "playing around?" (Fifth Journal Entry, Response)

Due to his limited class periods, instructional pace was always at the forefront of Brian's mind. As a result, he was constantly seeking ways to maximize his efficiency in the classroom. This posed particular challenges for Brian when considering how he might incorporate technology.

Yet despite these concerns, this passage reveals that Brian is willing to consider how he might incorporate the e-examples in his classroom. He is reflecting on his current concerns about technology and compares and contrasts these concerns to his ideas about and experiences with a new technology, namely the e-examples. He is beginning to "play out" what it would be like to weave the e-examples into his practice. In these ways, Brian

is engaging in *synthesis* – grappling with new ideas in relation to his current beliefs and practices, and considering a new course of action.

As in his exchange with Monique during the second study group session, Brian often used words like *struggle* to characterize his efforts to use technology in his instruction. Negative connotations such as this resurface during the next study group session when Brian discusses his experiences incorporating technology into his teaching of algebra. “We also use graphing calculators a lot and I *struggle* [italics added] with balancing being able to do it by hand with being able to do it on the calculator. It’s a *struggle* [italics added] for me to know when to do it by hand and put the calculators away and when to let them explore and use calculators” (Third Study Group Session). Later during the same conversation, in response to a comment by Callie that she would like to find a way to get all of her students into the computer lab at the same time, Brian commented, “So, what I think you’re talking is you would like to have something that your whole class could do at the same time... *It’s a difficult situation* [italics added] (Third Study Group Session). Similar notions about the difficulties posed by technology arise in Brian’s comments during later sessions. “I think from teachers’ point of view, all of this can relate to the fact that the calculator is easy, and kids will gravitate to what’s easy quite often. And, that *we have to work extra hard* [italics added] so it’s available to every student to get a calculator” (Sixth Study Group Session). Thus, although Brian was not averse to using technology in his mathematics instruction, and had experimented with various technological tools, his perspective on instructional technology seemed to be dominated by the many challenges he felt it posed for teachers.

Brian's comments during the early study group sessions and in journal entries also suggest that his view of instructional technology was closely tied to issues of developing students' computational skills. For example, during the fifth study group session Brian initiated a discussion by noting his agreement with the document's stance on computation and calculators.

Brian: Ok. I'll risk it, I'll say it. I liked on p. 32, "When teachers are working with students on developing computational algorithms, the calculator should be set aside."

Janelle: I agree with that, too.

Dawn: Where is that, Brian?

Brian: It's on page 32, at the very bottom.

Dawn: At the bottom?

Brian: Yeah, the last sentence. I guess I saw it as giving permission to do some back to basics type of instruction, or what would be seen as back to basics by the parents. I know that there's always a sigh of relief at open house when I say, "And some of the times this year your kids will not be allowed to use calculators. Please look out for that and don't let them." "Oh, yeah," they'll say. I'm sure they... *[inaudible]* too, but, I guess it's reinforcing, or reassuring to know that they're going to have that every year. (Fifth Study Group Session)

This passage was so noteworthy to Brian that he later cited it as the most important idea put forth in the Number Standard (Sixth Study Group Session). This tendency to consider calculator use and students' ability to compute as interwoven issues seemed to be due in part to pressures from and expectations of his community.

There's this big survey that they sent out to the community... Basically, the biggest correlation that they found was parents who thought that their kids could do computation without a calculator thought that [our] math program was good. That was the major correlation they found with that document. That was an outside person who didn't have any vested interests and that's what parents are thinking. They're so hung up on the

fact that if my kid can play with a piece of paper and pencil, then they must be good in math. (Second Study Group Session)

Brian revisited this link between parents' beliefs about their children's dependence on calculators to compute and their opinions about the mathematics curriculum in his journal.

The survey showed a positive correlation. In general, parents who thought their child could compute without a calculator felt our math program was strong. Parents who thought their child was weak in computational skills thought our math program was weak. There was no such correlation between feelings about problem solving or general conceptual understanding. (First Journal Entry, Response)

Thus, Brian's tendency to relate students' computational abilities with the use of calculators in the classroom is not surprising. His students' parents believed there was a connection, and their opinion of the CMP curriculum Brian taught from, and was an advocate of, was tied up in this belief. Indeed, a common criticism of the NCTM *Standards*, and of curricula like CMP that are aligned with the *Standards*, has been that an increased use in technology in mathematics classrooms will lead to a decrease in students' procedural fluency. Brian was aware of this concern, both within and outside his community.

Gradually, over the course of the study group, Brian's perspective on technology seemed to shift. He begins to recognize and appreciate the document's claim that technology should play a crucial role in mathematics instruction. Consequently, his comments about technology become more balanced, and he begins to highlight not just the difficulties, but also the advantages, that instructional technologies can afford. For example, consider the following passage in which teachers discuss the Geometry Standard.

Callie: There are a lot of things that mention, I mean a lot of times they [the Writers] will mention technology with the geometry, more so than I saw in any of the other areas that we've read. I guess I was kind of, I don't know if surprised is the word or not, but I don't use any technology for geometry, but I haven't done much geometry. But I never thought about using a lot of computer games, or not games but programs. Is it easier to teach geometry or is it just more to help kids understand what's going on?

Lara: Yeah, I noticed that, too. I wrote on page 32, "very heavy on technology."

Brian: Well, I think the reason that they're trying to do that more is because that's where we're in trouble. Geometry is about visualizing something that's not really there. And we saw it right up there – we were trying to explain it [one of the e-examples in the document], to draw these pictures that really don't move. And it's like, so this will move over here... But that's something that you can do on a screen so easily and it sort of pushes it around for you and it shows them more effectively than you could ever do with a drawing on a chalkboard. (Ninth Study Group Session)

During this discussion, teachers express their surprise at the extent to which the document advocates the use of technology as part of geometry instruction. Brian responds by defending the document's stance, arguing that technology enables students to visualize geometric situations that would be very difficult to represent two-dimensionally. Instead of pointing out possible difficulties that the technology might introduce, he notes that using technology in this way is actually more effective than traditional methods. Later during the same discussion, Brian comments on an electronic example accessible on the Internet that provides students with a visual explanation for the Pythagorean relation.

I liked the e-example with reflections, rotations, and translations. I thought that was a good one, talking about a small lesson that *you could do in a short period of time* [italics added]. That might actually be a good way to present it, especially if what Mindy says is true that the kids seem to get it pretty quickly. Maybe doing that in a situation on a day or two in the computer lab *would be as effective* [italics added] as doing three different group/class lessons. (Ninth Study Group Session)

Again, Brian comments on how technology could be used effectively to develop students' understanding of geometry (namely, geometric transformations). In contrast to comments he made during the beginning of the project, here Brian considers the possibility that using technology might help save time. Again, Brian is engaging in synthesis – thinking through how he might introduce the e-examples into his classroom practice.

Brian continued to make arguments for the value of technology in later study group sessions and in his journal entries. For example, during the eleventh study group session, teachers grappled with the document's claim that technology was *essential* in mathematics teaching and learning. Brian reasons through this claim, offering two advantages afforded by technology.

Well, getting back to the Technology Principle, the two things that are here... What makes it so useful is, one, you can do multiple things quickly; you can do multiple *[inaudible]* quickly. The other one is visualizing what you can't explain, you know, like the geometry stuff, and you can't really do that very well on the chalkboard, visually. (Eleventh Study Group Session)

In this passage, Brian reiterates a point he had proposed during a previous discussion, namely that technology has the potential to allow students to consider more examples more quickly, and to visualize geometric situations that are difficult to represent in two dimensions. By the conclusion of the group's discussion that session, Brian takes a stand in support of the claim that technology is necessary.

Dawn: I'm going to ask it again. Is technology essential? You [Tim] seem to be saying yes. [To the rest of the group] Essential?

Brian: I'd say given today's world, where computers are everywhere, technology is everywhere, that if we don't teach it, we're really shortchanging kids. I can't imagine that there is a parent out there who would say, "No, you shouldn't teach my kid how to use the computer." So

why are there parents out there that say, “No, you shouldn’t teach my kid the graphing calculator” when they can use them on the ACT.

Dawn: So, it’s essential for them to learn how to use the tools, or is it essential to learning the mathematics?

Callie: The tools, I think the tools, knowing how to use them.

Brian: Both. (Eleventh Study Group Session)

Here Brian introduces a new argument for the value of technology, drawing on the notion of equity. To prepare students for today’s technological world, teachers must help students learn how to use technological tools to explore mathematical ideas. Moreover, with some prompting from me, Brian goes further. Technological tools are not only necessary “content” for students to learn about; they are necessary tools for learning mathematics content. This was a radical notion for most of the teachers to consider; only a few teachers, including Brian, seemed ready to even partially accept it.

It is important to note that this shift to a more balanced portrayal of the constraints and opportunities afforded by technology did not mean that Brian no longer had concerns about implementing technology. Rather, he continued to struggle with how to maximize efficiency and prevent his students from wandering off task.

Well, I agree that it [technology] is great to use, but I think I wrote in my dialogue journal or talked earlier, that I have a hard time managing it. We go to the computer lab, but how do you make sure that everybody is doing what they are supposed to be doing? How do you make sure that your goals are being met or are the kids just playing around with other stuff? It’s just a managerial thing. I mean, the graphing calculators, I’ve gotten pretty good at managing those. But, still when I’m teaching new topics, I find that I’m always having to monitor to make sure that they’re not pushing any extra buttons, to figure out what’s going on here. And so, at the same time, I’m squelching their creativity and also making sure that they’re getting out... And when you’re working on a computer, you’ve got all these things that they can do at the touch of a button, how do you make sure that they’re on the right page? (Eleventh Study Group Session)

Thus, Brian was still grappling with some of the same logistical challenges that the use of technology posed. He is not satisfied with how he currently manages his students' use of technology (dissonance). Yet despite these issues not being fully resolved, Brian was exhibiting a greater willingness and ability to recognize the ways in which technology could support his mathematics instruction.

As he became more aware of, and supportive of, the document's stance on the critical role of technology, Brian began to make the use of technology a higher priority for his classroom practice. This is evidenced in multiple ways. First, in reflecting on the lesson on the area of trapezoids that he and his partner Mindy developed as part of their lesson study, one of only two revisions Brian proposed making for next year was to incorporate technology into the lesson. "I have been trying to envision an effective supplement with Geometer's Sketchpad software. I am not terribly skilled with this program, but this may give me impetus to improve my skills. If I get a few free moments in the next days, I will try to develop something." (Fourth Journal Entry) Second, when asked to compare and contrast his practice to the vision of mathematics teaching put forth in the document, Brian wrote:

I would like to think my classroom is fairly well aligned with the PSSM, but I have come to recognize several areas where I come up short: 1.) Use of technology: Although we use the graphing calculator often, it is our only regular application of modern technologies available to us. (Sixth Journal Entry)

Brian continued by discussing priorities for his practice for next year.

I hope to use more technology during the year. I am hoping to incorporate some of the e-examples from the NCTM website, as well as the Geometer's Sketchpad, if I can figure out a way to make it meaningful to my students. I would like to see if I could engage a few extra students, as well as give a deeper understanding to all students. Again, the trick will be finding time and computer lab access. (Sixth Journal Entry)



In this entry, we see that Brian now realizes that the use of technology is a critical component of the vision put forth by the NCTM. He has become more explicit about and dissatisfied with his use of technology ("I have come to recognize several areas where I come up short"), evidence that he is experiencing dissonance. This recognition leads him to identify a new area for improvement in his own teaching and to consider some of the ideas and examples put forth in the document, an indication of synthesis. This is noteworthy, for recall that Brian had not initially expressed an interest in incorporating more technology as one of his personal goals, nor had he identified the use of technology as something he would expect to see in a mathematics classroom aligned with the *Standards*. Moreover, his comments indicate that he is considering moving past synthesis and into the *experimentation* phase.

Brian's new commitment to technology is also evidenced in his response to an assignment in preparation for our presentation at the annual NCTM conference. In response to the question, "What impact has the [study group] experience had on your knowledge, beliefs, classroom practice, future goals for your practice or for professional development, etc.?" Brian wrote:

**Beliefs:** The importance of technology has become more evident to me.

**Classroom Practice:** I am always looking for new ways to involve technology. This year, my evaluation project focused on developing math lessons with our computer coordinator. By the end of the year, we hope to have a document for teachers in our building to make Internet lessons more approachable.

**Future Goals:** Continue pushing computer and Internet options in my teaching. (NCTM Homework Assignment)

Brian's discussion of an evaluation project under "Classroom Practice" refers to one of two efforts that Brian undertook on his own initiative, during and after the study group sessions. In his district, tenured teachers like himself could opt out of the standard classroom observation and evaluation by the principal and instead design their own professional development experience to address their particular needs or interests. Brian decided to take advantage of this option during the year the study group was meeting. Working with the school's computer specialist, Brian developed lesson plans around CMP lessons that incorporated technology (such as applets already available on the Internet), and submitted this work for evaluation by the principal. The following school year, he continued to work with the computer specialist to develop a library of web-based mathematics lessons for his building. Thus, Brian is engaging in experimentation – he is piloting a new use of technology and collecting some evidence to evaluate its effectiveness.

Brian continued to engage in the work of designing lesson plans incorporating technology during the summer study group sessions. During the first summer session (the twelfth session), teachers decided they would like to spend part of their time developing a lesson plan around one of the electronic examples<sup>2</sup> in the document. Brian volunteered to take the lead on this initiative, and the group continued to meet into late September without me. By October, the group had disbanded, yet Brian continued work on the lesson plan, including efforts to have it posted on the Internet. He taught the lesson in December of that year, partnering again with the school's computer specialist and having the lesson videotaped. Based on information he collected from this implementation, he

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<sup>2</sup> E-example 6.3, Linking Length, Perimeter, Area, and Volume (NCTM, 2000, p. 235)

then revised the lesson for next year. Throughout that fall and winter, Brian posted occasional emails to the listserv, keeping the rest of the group informed of his progress and what he was learning by. Thus, Brian continued to engage in experimentation outside of the study group.

Brian's efforts to interweave technology into his teaching, through his efforts to develop new lesson plans at school and within the study group, reflect a new investment in the use of technology. Before participating in the study group, Brian had experimented with various instructional technologies in his classroom but had not become a strong advocate of them. In discussions with the study group and in his journal, he primarily shared feelings of frustration toward the difficulties and demands posed by technology use. Concerns from parents and the broader community encouraged him to concentrate on issues surrounding the use of a particular form of technology, calculators, and students' computational abilities. Moreover, he did not seem to be aware of the bold stance that the NCTM had adopted regarding the role technology should play in mathematics education. Through studying the document and discussing it with his peers, Brian both broadened and deepened his understanding of instructional technology. He moved beyond initial concerns about the connection between students' dependency on calculators and their computational skills and began to identify the advantages technology could offer. And, he became inspired to find ways to weave more technology into his teaching.

### Summary: Impact on Brian

What can be said about the impact of Brian's participation in the study group and analysis of the document on his beliefs, priorities, and practice? First, Brian developed a greater commitment to the use of technology in his instruction. He became more cognizant of the advantages that technology afforded and less skeptical of its use. Consequently, he took steps to incorporate more technology into his classroom. He formed a partnership with his school's computer specialist and began to develop a series of web-based lesson plans, including one designed around an electronic example in the document.

Second, Brian grew very interested in becoming a teacher leader so that he could play a more active role in his community and school district.

Well, what I've already done is we had some leftover money in our budget and I got a flyer - I don't know if you saw the books in my room - but I ordered three or four titles about lead teaching and supporting teacher development or whatever, and will look through those this summer. Because I feel that there's a need in our district - it's not just our program - to do mentoring on a continuing basis, you know, peer assessment or coaching or whatever. I mean it's just never gotten off the ground and I would like to see that happen. And I guess I'm going to have to realize that it's not going to happen unless I sort of step up to the plate and push the issue. Maybe next year is the year for that. (Interview, May 2, 2001)

For Brian, this meant pursuing more stimulating professional development opportunities. He was most interested in trying to develop a community of teachers similar to our study group.

I am pursuing some professional development at our two middle schools for math teachers. I think our principal would be supportive of having us study the *Standards* as part of our required professional development. If so, we could use our work to provide further examples of how to use PSSM for staff development. (Email Correspondence, October 23, 2001)

Brian has new priorities for his role as a professional and for his continued professional learning.

In terms of Ross and Regan's (1993) model, we see Brian participating in each of the four stages of professional learning. First, he experienced some dissonance in comparing his initial view of technology to that proposed in the document's Technology Principle. He begins to feel dissatisfied with his failure to do more with technology, especially when a passage from the document reminds him how fortunate he is in terms of district resources. During the study group discussions, he begins to develop arguments for the advantages technology affords. Doing so involves synthesis, in that he is modifying his current understanding of instructional technology to the ideas about technology put forth in the document. He engages in experimentation when he develops and implements a web-based lesson plan as part of his yearly professional development. Finally, by continuing to design and implement lessons incorporating technology, Brian begins to internalize technology use as a regular component of his practice, thereby engaging in integration.

## CHAPTER 6

### THE CASE OF JANELLE

Maybe that's part of this, too, is that this document is a teaching tool as well. It's not just setting up standards, but teaching [us]. Because I really put myself in a learner situation and I actually learned a number of things that I didn't know before, that I hadn't thought about in this way. So, I kind of like that, I absorb it. (Third Study Group Session)

This chapter presents an account of Janelle's participation in, and learning from, the study group. Janelle's story is one of an inquisitive middle school mathematics teacher who enjoys learning and describes herself as "intellectually curious" (Interview, May 9, 2001). Janelle's story is the story of a teacher who is teaching from a self-designed mathematics curriculum in an urban K-12 charter school. Janelle's story is the story of a teacher who came to the study group unfamiliar with *Principles and Standards*. By exploring Janelle's case, I can explore the potential of the document to stimulate and be meaningful to mathematics teachers who are not supported by a well-developed, *Standards*-based curriculum and who are not initially familiar with the document's vision and recommendations for mathematics education.

The chapter begins by describing relevant background information about Janelle – her teaching experience, school context and curriculum, motivation for participating in the study group, and incoming awareness of and ideas about the NCTM *Standards*. Next, the interpretations and key ideas that Janelle developed about the document are identified and elaborated. The chapter concludes with a discussion of what impact, if any,

participating in the study group had on Janelle's beliefs, knowledge, and priorities for his classroom practice.

### **Background Information**

Janelle had been teaching for ten years, with the last five years spent teaching mathematics in grades six and seven. She had earned a bachelor's degree in English and held both K-6 and 7-12 certification. She had also completed some graduate work in education at a local university. Janelle demonstrated a genuine interest in and enjoyment of mathematics during the study group sessions, and a strong desire to learn more about how to improve her teaching. "I love teaching math and am always looking to add to my expertise" (Application, Question 3a).

At the time of the study, Janelle was teaching sixth grade in a self-contained classroom in a public K-12 charter school in the heart of a large city in mid-Michigan. She was a lead teacher in her building and had been at the school since its inception. The building has no set mathematics curriculum. Thus, mathematics teachers were left to assemble their own materials, often borrowing and adapting pieces from more than one mathematics curriculum series. However, Janelle and others were working to align their curriculum with a county curriculum framework she had acquired when serving as an interim principal at another school the previous year. Janelle reported having three goals for improving her teaching: 1.) Become very familiar with the document, so that she can share its vision and recommendations with her colleagues and use it to guide alignment of their curriculum, K-12; 2.) Learn new ways to improve her teaching; and 3.) Experiment with new ideas and then solicit feedback from the group (Application, Question 3b).

Helping students see that mathematics is more than computation and is applicable in the real world were her goals for her students. Janelle was particularly excited about the opportunities for sharing and learning from other middle school mathematics teachers. "I would enjoy meeting and working with like-minded individuals! I want to share my ideas and gain knowledge from colleagues" (Application, Question 4).

In her application to the study group, Janelle reported that she was aware of, but not at all familiar with, the NCTM *Standards*; she was more familiar with the state's curriculum standards and with the county curriculum framework. In describing what she would expect to see in a middle school mathematics classroom that was aligned with the *Standards*, Janelle wrote:

I wouldn't expect to see students working on pages of problems. "Today, we're adding fractions. So, here are 40 to do." The room would have lots of tools around – scales, calculators, compass, protractors. The walls would show work that had been done. Here are the five presentations made by the five groups which include their models or graphs of their work. ... There might be an overhead or a power point presentation being given by students. The teacher would facilitate discussions to enhance the presentations. ... Questions like: "Based on what you see here, what might happen if we change this factor or variable? Do you see a pattern? Students would present ideas – then test them out with the class. Many of their [students'] statements might be "I wonder" statements. "I wonder what would happen if..." The curriculum would be rigorous. I guess I think I'd see lots of "real world" kinds of problems. (First Journal Entry)

In this description, Janelle portrays a classroom that is student-centered: students are giving presentations at the front of the class and are discussing their ideas publicly. Students are encouraged to explore and reason about mathematics, rather than practice solving large sets of similar problems. Thus, although she describes herself as not knowing the *Standards*, she seems to have already developed a few ideas about the vision of mathematics teaching and learning they portray. In particular, she viewed the



documents as providing direction for where her teaching should be headed. "I am also aware of the *Standards*, and I wish to be aware of my responsibilities in providing a *great* math education." (Application, Question 3a).

### **What Ideas Did Janelle Develop about *Principles and Standards*?**

In this section, I discuss some of the key ideas that Janelle developed through her study of the document in the study group. I begin by describing Janelle's overall impressions of the document and the ways in which she came to view the document and its purposes. Next, I trace Janelle's ideas about a central theme that arose from the document and that became salient to her, namely the notion that students should be allowed to explore mathematics problems before being given an algorithm to solve them. Finally, the section concludes with a summary of the impact the study group had on Janelle.

### **Overall Impressions**

Janelle took great pleasure in her study of the document. She especially enjoyed the collaborative nature of the study group because it pushed her to be explicit about her own understanding to the other members. "A book study is powerful in that participants go beyond the reading to explain their understanding and then to apply understanding. Much sharing of ideas and practices as they related to the document assisted me in gaining a deeper, more readily usable knowledge" (NCTM Homework Assignment). Janelle also took comfort in learning that others in the group shared similar struggles (Interview, May 9, 2001). She saw the document as validating some of what she already

believed and was doing. “Many of my own beliefs and practices were confirmed by our study [of the document]. As an example, I believe in authentic assessment through project learning and oral presentations” (NCTM Homework Assignment).

Janelle was especially drawn to the mathematics tasks in the document. “The book sits well with me. I am learning a lot. I relish the reading, especially the specific standards with the problems. I like doing the problems” (Third Journal Entry). In fact, Janelle would often spend her free time outside of the study group sessions trying to tackle various problems posed in the document. She also took some of the problems into her classroom and used them in her teaching. “Each morning with start with a challenge – today, I did (a) on p. 215 [of the document] – fraction strips” (Third Journal Entry).

Janelle’s comments during the study group sessions and in the journals indicate that she found her study of the document to be stimulating. The document was able to pull her in, so that she felt like she was “there”.

I often felt that I was “there” as I read the document, especially in the process area [Process Standards]. I need to add so much more and limit my computation time. It’s tricky, because of my memories of my daughter who doesn’t know math facts or computation and went from all A’s to D’s. She doesn’t believe she can do it. (Sixth Journal Entry)

On at least two occasions, Janelle reported feeling exhilarated by the study group sessions.<sup>1</sup> For example, during the interview she talked about coming back from a study group session feeling “angry, upset, worked up” by one of the group’s discussions that night. Apparently her eighteen year-old son was at home at the time, and his reaction had

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<sup>1</sup> Janelle described both of these occasions to me during our interview. She seemed uncomfortable in having me audiotape the interview, so I put the tape recorder away and took field notes. As a result, I only managed to capture brief segments of her actual talk; the majority of my notes are a summary of her comments.

been, “Well, mom, that’s good that you got worked up by this. That makes you think more!” Janelle agreed with him, and even though she still felt angry at the time, she realized that in the end she appreciated the group for pushing her thinking. On another occasion, Janelle reported returning from a study group session with “all this stuff just zipping around in my head!” That night she had trouble sleeping because she couldn’t stop thinking about the night’s discussion (Interview, May 9, 2001).<sup>2</sup>

### **Ways of Viewing the Document**

Janelle’s comments during the study group sessions and in her journal entries indicate that she envisioned using the document in two ways: as a tool for her own learning, and as a *curriculum map*. I elaborate on each of these in turn.

Janelle’s comments in her application to the project and in her early journal entries reveal that one of her primary goals for participating in the study group was to improve her teaching. For example, when asked to discuss her specific goals for joining the study group, Janelle wrote, “Specifically, I’d like to focus in on sixth grade to enhance my own teaching. I want to share with my colleagues in this project. I want to learn from them” (Janelle, Second Journal Entry). The quote from Janelle that opens this chapter reveals that in addition to the collaboration among colleagues, she also found the document itself to be a valuable tool for her learning.

Janelle’s primary strategy for learning from the document involved borrowing and trying out mathematics tasks she found in the readings. She frequently requested that we spend time in the study group sessions working on math problems as a group or

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<sup>2</sup> Unfortunately, Janelle could not recall the specific topic under discussion during either of these occasions.

discussing problems teachers had worked on at home. For example, at the beginning of the twelfth study group session, when the teachers and I were planning our agenda for the summer meetings, Janelle suggested, “Maybe we can take some of the problems that are in the document and figure out ways to develop them. I was working on one last night and got stuck and could use some help on it. There are some very cool examples so maybe we could pick out a few and figure out how to bring them into the classroom” (Twelfth Study Group Session). Indeed, in describing what she felt she learned from studying the document and participating in the study group, one of the things Janelle cited was, “I was exposed to many rich problems which taught me what rich problems are. I enhanced my understanding – I used many [of the problems] in my own class” (NCTM Homework Assignment).

Janelle reported implementing at least three of the tasks that came directly from her reading of the document, as well as a few that she borrowed from other teachers’ lesson study projects. As she implemented these tasks, she also experimented with different instructional strategies, such as honing her questioning technique, or guiding students without doing all of the work for them. For example, in the clip below, Janelle describes her experience in providing students’ with “hints” as they solved a particular task she had borrowed.

And sometimes in the process of things they’ll say, “Could you give us a hint”? And occasionally I do and the last time I did that I then, they evaluated whether the impact of my hint on their process. It was actually very interesting and they made very good comments. Yes, it changed the whole thing. It let me know by what you said, it let me know in advance the conclusion that I should come to and while that’s comfortable maybe it wasn’t [*Inaudible*]. So, I consider that, I never ever think of myself as close to perfection, but I think of it as one of those times when I took the right path. (Seventh Study Group Session)

Thus, the tasks Janelle borrowed provided her with a context in which to test the effectiveness of some instructional techniques.

Janelle also felt that teachers could learn from *Principles and Standards* through being exposed to and reflecting on the ideas put forth in the document. For example, during the third study group session, the teachers were discussing the ambitious goals put forth by the document in the grade band for grades 3-5, and how elementary school teachers would need support deepening their knowledge of mathematics. During this discussion, Janelle repeatedly offered the document as a possible source for developing elementary school teachers' knowledge.

I just have one other thought. I think that on the topic of, you say the elementary teacher with not as much math background. I think all of this is learnable, and I don't see that that should ever stand in their way. I think it's *all* learnable. I don't think you have to be a math major to, to make yourself knowledgeable. ... So, I, I think, you know *if you can find the same page* [italics added] [pointing to the document] and give the time to share that, and I think all the knowledge can be had and I don't think it should ever be an excuse that so and so doesn't have the background, therefore... (Janelle, Third Study Group Session)

In this passage, Janelle argues that every teacher is capable of learning the knowledge they need and that one possible avenue for doing so would be to "find the same page" in the document and take time to "share", a notion similar to the process our study group was undergoing. She reiterates similar ideas later during the discussion.

I wouldn't recommend that, and nothing I was saying suggested this or I didn't mean to if I did, that somebody who is teaching first or second grade math should get up there and start doing Calculus up here in order to do this. I kind of like more your idea [referring to Edgar]... that this person back here has some fun with negative numbers and kind of gets some idea of how that can come out, how that can be incorporated, how it's more than just recognizing the numbers on the number line, this and then adding three plus one and then taking away three minus one, but there's some other stuff to it. And to me, that's where, that's what this thing is saying to me. [Pointing to the document] It's thinking bigger,

thinking broader, I guess. And so, I don't think it means going back to school, I think it means doing it in a different way. (Janelle, Third Study Group Session)

In this clip, Janelle suggests that the document indicates what and how teachers should learn, and that this learning would involve playing around with and exploring mathematical ideas. Such learning should involve “thinking bigger” and “broader” than simply taking additional course work like Calculus. Thus, Janelle envisions the document as a tool for teacher learning in several ways – as a source of rich problems that teachers can try out and learn from, as a “textbook” that teachers can study and learn from (through sharing with others), and as a guide to what and how teachers should continue to learn.

In addition to viewing the document as a tool for teacher learning, Janelle also envisioned using the document as a *curriculum map*, a tool for analyzing, designing, and selecting mathematics curricula. In particular, Janelle hoped that the document would assist her and her colleagues in aligning their K-12 curriculum to state and county frameworks. (Recall that Janelle worked in a charter school in which all grades, kindergarten through twelve, were taught in a single building and that had no set mathematics curriculum series.) For example, in describing her goals for participating in the study group, Janelle wrote, “I want to know very well the document so that I can teach and inform my colleagues as we work toward a K-12 alignment of Math curriculum (Second Journal Entry). She reiterated this interest in curriculum alignment in her next journal entry:

I am interested in seeing how the subject is organized K-12 – I want to see how it all connects. This is one of the things that is provocative for me.... At our school, we have set up our curriculum K-12 in terms of what the “learner will do.” We are attempting to line it up with state and [name of

county] guidelines. We don't want to repeat or overlap material ineffectively. (Janelle, Third Journal Entry)

Thus, Janelle came to the study group hoping that her study of the document would help her develop a better perspective on the K-12 mathematics curriculum in its totality, and that this informed perspective would support her and her colleagues in aligning their own curriculum.

Interestingly, Janelle associated “*Standards*-based” teaching with “aligned teaching”. In her first journal entry, in which she was asked to describe what they expected to see if they were to spend a week observing in the classroom of a mathematics teacher whose instruction was aligned with the NCTM Standards, Janelle responded:

Teachers, aligned or not, are as different as can be imagined. I really might expect nothing or any number of possibilities. However, aligned teaching, teaching with an awareness of the big picture K-12 is often *good* teaching. It is purposeful and perhaps not bound by older teaching standards and styles. (First Journal Entry)

Thus, for Janelle, “good” (mathematics) teaching was teaching that was informed and guided by “an awareness of the big picture K-12”, so that it aligned with instruction that was occurring in the grades before and after, and did not include unnecessary repetition of material. Engaged in efforts with her colleagues to develop this type of teaching in her own school, Janelle was seeking guidance and advice in how to do this, and saw the document as one good framework for guidance.

Janelle reports that her study of the document did help her to develop a better sense of how mathematics is developed across the grades. For example, in her sixth journal entry, Janelle wrote, “The Principles and Standards have helped me not only with the big picture, but the connections and relationships throughout” (Sixth Journal Entry). This idea of seeing the connections and relationships within school mathematics

reemerged in her discussion of what she felt she learned from participating in the study group. “I began to look at the content and process standards as woven through all grades K-12. Algebra was not a middle or high school subject, but a way of knowing taught in all grades (NCTM Homework Assignment). Thus, Janelle began to see how a mathematical idea or topic like algebra could be traced and developed through the grades. Janelle’s new understanding of the big picture of curriculum seems to have had a tangible impact in her school. By the fall of the next school year (the semester after the study group’s summer sessions), Janelle’ school had adopted a *Standards*-based middle school mathematics curriculum, and she had taken on a leadership role in the building.

My role at Williamtown changed this year. I have stepped from the 6<sup>th</sup> grade classroom to become lead teacher in middle school, which includes grades 5-8. The impact I have made based on our study is to assist new and veteran math teachers as we worked to develop a consistent math content progression through the middle years. We have adopted the Connected Math Project. Three math teachers are registered for CMP’s summer workshop. We have attempted to go deep with learning instead of wide, working major concepts slowly and thoroughly, rather than rushing to get through everything in the “book”. Prior to this year, math teaching was based on the Kroll curriculum, an aligned curriculum created by [name of county ISD]. The delivery system was haphazard and fragmented at best, with each teacher using his/her own materials. This year has been a start with much still to do. (Janelle, NCTM Homework Assignment)

In the next section, I present discussion and analysis of a key issue that became central to Janelle as she studied the document and participated in the study group discussions, namely the importance of letting students explore mathematical ideas before giving them algorithms. This issue has its roots in the recommendations put forth in the document, and in the teachers’ ensuing discussions. Discussion of how Janelle came to identify with this issue will highlight how Janelle’s study of the document and



participation in the study group discussions helped her to move through at least three of the four stages of professional development – dissonance, synthesis, and experimentation.

### **“Exploration” before Algorithms**

According to Janelle, one of the most important ideas that she took away from her study of the document and participation in the study group was the notion that teachers should give students ample time to explore mathematical problems and develop their own solution strategies before giving them the algorithms and procedures. This idea was first taken up by the group during the third study group session, in which I asked the group for their reactions to a particular statement in the overview to the Algebra Standard (Chapter 3 of the document).

Dawn: Um, page 39. It's in the last paragraph, before the section “Use mathematical models”... which I thought, well this is, I thought was a strong statement. It's toward the end of the paragraph. It says, “In general if students engage extensively in symbolic manipulation before they develop a solid conceptual foundation for their work, they will be unable to do more than mechanical manipulations.” That's actually quite similar to the quote that you [Brian] had read before.

Brian: I had it highlighted with two exclamation points as well.

Kayla: And the last sentence, that is should be laid over a long time. I think that's hard for districts and individuals to wrestle with. How much time, where does it begin? (Third Study Group Session)

Unfortunately, Edgar shifted the topic to a new central theme, and so the teachers did not have an opportunity to respond to my question. However, this idea that conceptual understanding should be developed before engaging students in extensive symbolic manipulations reemerged during the next study group session. The discussion began when Lara quoted the following passage from the Teaching Principle: “Teachers must

also decide... how to support students without taking over the process of thinking for them and thus eliminating the challenge” (NCTM, 2000, p. 19).

Lara: I liked this, this kind of applies to science, too, which I teach. It says, it's also in the teaching, it says, up at that top part about the professional development. It says how to “support students without taking over the process of thinking for them and thus eliminating the challenge” [p. 19]. Sometimes they, sometimes they just so much want the shortcut and will just give me the answer because that's what they're so used to. That really, that struck a chord with me.

Monique: Joyce and I were just talking about that on our way here. That some of our students were working on the,  $2 \text{ halves} \times \text{plus one third equals}$ , you know. And they'll be like, “Okay, do I add or subtract? Which one do I flip? Do I have to make it...? And they don't even care. I mean, it's not even like they really understand the process. They just want to know the steps and they just want to do it. They don't *want* to understand it. Joyce was saying that she tried to go through and I'm like estimate and she thought that they got it. But my honors kids were just like, “We don't even care. Just tell us what to do so we can do it.”

Dawn: Where does that come from?

Tim: Parents

Brian: Previous experience

Someone: Experience in schools

Joyce: Well, I think that's how we've taught it... (continues) (Fourth Study Group Session)

Lara and several other teachers reacted to this statement by discussing students' resistance to being asked to think about mathematics problems and the pressures they exert on teachers to just tell them how to solve the problems. Joyce enters the conversation and shares a recent story from her own classroom in which she tried to “slow down” and help students make sense of the problem at hand instead of rushing to introduce an algorithm. In response to Joyce's story, Brian describes a research article he recently read that he finds relevant to the conversation.

Brian: There was an interesting study that was published I think in last month's Journal of Research in Mathematics Education. They did a study, they taught elementary fifth graders how to do area, perimeter, basic geometric, using just here's the formula. And they taught it I think for two weeks or three weeks and they did a unit on that. And they taught it to them and at the end, they were tested. And then they did that same unit again about 6 months later in the spring. Except instead of teaching it, here's the algorithm, they did it like, cut out the pieces, put it together, you know, hands-on activities. But they taught it for a shorter period of time. But the second time, they taught another school, another test group of kids and that was their first time. So, this group over here had had it twice—once the traditional way and then with the hands-on activity half as long. This group over here had the hands-on activity for half as long. So, the difference is that they've [the first group of students] had it twice. At the end, they post-tested which group retained more and did it better. The one that was taught twice? No. The one that was taught once. So, that article says something about we're interfering with their understanding and to do so we're actually putting a wall there, when we give them the algorithm. Because they no longer feel they need to understand it because they know the equation. So, it was really pretty startling to see the results. I'll try to get that.

Edgar: Well, it takes a lot more practice to unlearn something that you learned wrong than to learn it right the first time.

Brian: Yeah. And there was a whole bunch of explanations about why this might happen and it was really quite eye opening. And it makes you think twice about, you've got to be careful about *what* you teach because you can actually be getting in the way more than actually teaching. (Fourth Study Group Session)

The teachers then go on to briefly react to the research study that Brian described. The conversation ended (due to time) with the following comment from Brian:

Brian: Well, the repercussions of that article, I mean, I don't know if I'm going to go to any parent who happens to teach their kid the algorithm before we get there because they think they're doing their kid a favor. You know, I'll show you, all you have to do is flip and multiply instead of doing division. Are they, you know, I want to be able to show this article and say, "You're actually hurting your kid when you're telling them, 'Oh, you just cross-multiply and divide and...'" Rather than teach them another way that... I'm sure that they would not like that. (Fourth Study Group Session)

Although Janelle never directly participated in either of these discussions, the ideas taken up seem to have had a significant impact on her thinking, and eventually, her teaching.

For example, soon after this study group session, Janelle wrote about this notion of giving students time to explore problems in her journal.

I think one of the biggest changes in my thinking is about giving the algorithm then solving problems, rather than thinking about things first without the rule or formula. I have to work at this a bit because I've learned it the other way. I think it's quite an art to guide students in this direction (Janelle, Fourth Journal Entry).

Janelle seems to be intrigued with this idea of postponing the introduction of algorithms (dissonance), but recognizes that implementing it will be challenging, for two reasons.

First, it runs counter to how she learned mathematics. Second, it requires guiding students in a different way. Soon after this entry, Janelle reported that she had begun to introduce this practice in her classroom, and that she was finding this change beneficial (experimentation stage). For example, when I asked to describe how her new understanding of the document has influenced her, Janelle wrote:

One of your last journal questions – how has new NCTM knowledge changed my teaching – The #1 biggest way has to be in the “non-algorithm first” way. “Here, I’ll show you how – then practice!” It will take me some time to reverse the engines, but I am committed to the change. One of the boys in my class who was doing sixth grade for the second time (I had three) said that he now loved math and had been very unsuccessful before. It moves me to get lots of kids to that place. (Sixth Journal Entry)

In this passage, Janelle reports that her students’ attitudes toward mathematics are improving as a result of her giving students time to explore problems before teaching them the algorithm. Collecting this type of evidence is compelling to her, and she becomes more committed to the approach.

Janelle continued to describe her attempts to adopt this “explore first, algorithms second” approach in the study group discussions, arguing that this approach requires that the teacher be a “master” at questioning.<sup>3</sup>

I think when you become an artist as a teacher is when you are a master at questioning and fielding things on your feet and knowing how to turn things subtly different directions when you need to. And, maybe even stop them if you need to. For me, it's an art form and it takes, it doesn't matter what subject you're teaching, it just takes a great deal of skill and practice. I personally don't have the sense of time constraints that you feel. I'm not pressured by parents as far as curriculum. Most of the parents that I have consider me the expert. And I mean it's sort of humorous to me. But, I don't have anybody that ever questions what I do. And if I have read this [the document] correctly, it's seems like this kind of work, taking this kind of time, is time well spent. And so, for my sense of things, working through their ideas, working through their logic-ing it through, working through, taking the time to have them talk to each other, become the teachers, to me, is time well spent. And maybe it is a luxury that I have that some don't in terms of, you know, just the pressure to produce you know x amount of chapters. And I don't have any of that. I have no books. I have no particular curriculum other than the one that I have created. And you may be sitting in shock and wondering how abhorrent this is! But there is something that's somewhat freeing about it, too. (Janelle, Tenth Study Group Session)

In this passage, Janelle recognizes that to adopt the “exploration first” approach puts new demands on teachers in terms of their ability to ask good questions and manage students as they struggle to make sense of mathematics. She acknowledges that, unlike most teachers, she has the freedom to experiment with this “exploration first” approach because she has no set mathematics curriculum and experiences no undue pressures from parents. As she continues to describe her thinking about this approach, she reflects on the effects it might have on her students’ attitudes and thinking.

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<sup>3</sup> This approach of trying something new in her classroom and then reporting back to the group was one of the goals Janelle set for herself at the beginning of the study group. “I want to try things I’ve taken from this table in my classroom right away, so that I can get and give feedback” (Janelle, Second Journal Entry).

And I think the students that I teach need, I think some of them like math because there is this, this is right, and this is wrong. This is right; this is wrong. But some of them hate math because of that, because they've always been on the wrong side of the tracks. So, a lot of the times that I have spent this year is, let's listen to the ideas. Let's turn a mistake into a problem. And let's not jump on each other. Let's solve it together. Let's think this through. Let's think of this as logical and we're smart and we want to learn, you know. So, I... The whole thing kind of fits for me, intellectually. And I'm going to work on my art in terms of questioning, because when I am really good at that - and Dawn I thought was very good in my class, by the way, a little compliment for you. Because I turned the tables on her when she came to my class and I said, why don't you teach a little activity? And, they just, the kids ate it up of course!

(Laughter)

They did! They wanted to know when she could come back! But, one of the things she did very well was that she got them to talk. Does this work? Instead of just nodding her head, yup, that's right. She said, "Well, does this work all the time? Do you see something happening here?" Anyway, and it just forces such a different kind of thinking that I think is, I just think is so critical. I'm real intrigued by it and I'm going to work on my art and my craft, continuing to get better. (Janelle, Tenth Study Group Session)

In this passage, Janelle describes the changes she has been making to her instruction and again highlights the important role that teachers' questioning plays. More and more invested in this approach, she is determined to work on her questioning "craft".

Observing me teach her class provided her with a model for what this type of questioning might look like.

It is important to note that Janelle's new commitment to the "exploration first" approach does not translate into her devaluing algorithms and practice. Rather, it is a matter of sequence for her, of which should come first instructionally.

Dawn: I want to be careful that we're not all. And I hope, I don't know, maybe we are, but... (*Janelle says no.*) To go back to what Joyce is saying, that we're not saying everything, especially, and that's a big critique of Mathematically Correct, is that they push it to that extreme and would argue that NCTM is saying kids have to discover everything. You

learn *everything* by discovering and exploration and you can't ever tell and you don't ever teach a skill first, or things like that. I mean, it will be interesting to see if that's what people feel like that's what's coming across in this document, but I would think that, that's not what was meant to come across.

Janelle: I don't think so. For me, if I were to kind of take it down, it's the idea of not always doing the algorithms first, doing some things that investigate your way to it. Not, you know... But, yeah, I think that's it. That's the shift for me; that's the big shift in all of this. But, I don't, I'm not, I believe you have to practice things to get good at them. Once you even know how to do them, you still have to practice to get good at them. And I say to some kids, look, you're on the five-yard line now. You understand what's going on here, but now you have to practice it. You know, go all the way through, and then you'll have it. So, it's not to deny any of those other parts. I just think that, basically too much is way the other direction, way the other direction... (Fourteenth Study Group Session)

Janelle describes her understanding and commitment to the “exploration first” approach as a “big shift”. However, she still recognizes the importance and role of practice. For her, it is more a matter of the order – exploration first, then procedures and practice – and of balance between the two. Too much of either exploration or practice is inappropriate.

A final point: it is not clear if this idea became salient to Janelle because it was discussed in the document, or because it was taken up in the study group discussions, or because it was discussed in a research article and was supported by compelling empirical evidence. What is interesting, however, is that Janelle seems to at times directly attribute this idea to the document. For example, in their eighth journal entry, teachers were asked to respond to the following prompt: “If you were inquiring about a person’s understanding of the PSSM document, what questions could you pose to grasp their understanding of the messages of the document?” In response to this, Janelle wrote two questions in her journal, one of which was, “Which comes first, the algorithm or the

exploration? Explain!” Thus, Janelle seems to consider this idea as fundamental to a person’s understanding of *Principles and Standards*.

### **Summary: Impact on Janelle**

What can be said about the impact of Janelle’s participation in the study group and analysis of the document on her beliefs, priorities, and practice? First, Janelle seems to have developed a better understanding or “big picture” of the K-12 mathematics curriculum. She began to see curriculum as an interweaving and development of particular mathematical ideas across the grades, rather than a collection of discrete topics. Within such a curriculum, she learned what it meant for a problem to be “rich”, and she tried out some of these problems in her own classroom.

Second, and perhaps most importantly, Janelle developed a new perspective on mathematics teaching and learning, namely that allowing students to explore mathematical problems and devise their own solution strategies before giving them the algorithms supports their development of conceptual understanding and critical thinking. Janelle experimented with this “explore first” approach in her own teaching, and gradually became more and more committed to it, citing it as the most important thing she learned through studying the document with the study group. “This one is the most important to me. I learned that the algorithm first then practicing is not the best way. Research supports the notion that doing the conceptual understanding and exploration first is more powerful and leads to deeper learning” (Janelle, NCTM Homework Assignment).



In terms of Ross and Regan's (1993) model, we see Janelle participating in at least three of the four stages of professional learning. Confronted with the document's claim, and the supporting evidence from research, that algorithms should not be introduced until students have had sufficient time to explore problems on their own, and recognizing that this is in conflict with her current practice, she experiences dissonance. She begins to consider this "exploration first" approach for her own teaching and identifies some new mathematics tasks she can use. Doing so involves synthesis, as she is adapting her current understanding of her practice to accommodate this new approach. Janelle engages in experimentation when she pilots these tasks and this new approach in her classroom. Finally, there is some indication that Janelle is moving into integration, as she becomes more and more committed to the "explore first" approach.

## CHAPTER 7

### THE CASE OF JOYCE

I think that the document will have a different impact on each reader depending upon their [sic] particular situation and needs. Reading it again next year will probably affect me in different ways than it has this past year. Even as I reviewed sections of it in preparation for our presentation, I found new understanding (and questions) that I did not find the first time I read it. I view it as a learning tool that can be a continual resource for teachers who are interested in growing professionally. I hope that we can encourage other teachers to invest their time in its reading. What everyone will learn will vary, but I think we can guarantee that it will be a worthwhile learning experience for anyone who takes advantage of the opportunity. (Joyce, NCTM Homework Assignment)

This chapter presents an account of Joyce's participation in, and learning from, the study group. Joyce's story is of one of an experienced middle school mathematics teacher who is teaching from the *Saxon Math* curriculum in a rural middle school. Joyce's story is the story of a teacher who has already developed some awareness of the *Standards* by reading portions of *Principles and Standards*. Joyce's story is the story of a teacher working in a district burdened by many challenges. By exploring Joyce's case, I can explore the potential of the document to stimulate and be meaningful to experienced mathematics teachers who are implementing a very traditional curriculum and who are already somewhat familiar with the document's vision and recommendations for mathematics education.

The chapter begins by describing relevant background information about Joyce – her teaching experience, school context and curriculum, motivation for participating in the study group, and incoming awareness of and ideas about the NCTM *Standards*. Next,

the interpretations and key ideas that Joyce developed about the document are identified and elaborated. The chapter concludes with a discussion of what impact participating in the study group had on Joyce's beliefs, knowledge, and priorities for her classroom practice.

### **Background Information**

Joyce has been teaching for ten years, with the last seven years spent teaching middle school mathematics and science. She holds a bachelor's degree in social work and a master's degree in teaching, and is certified to teach all subjects in grades seven and eight, and mathematics and social sciences in grades nine through twelve.

At the time of the study, Joyce was teaching eighth grade "basic math", Pre-Algebra, and Honors Algebra in a public middle school in a rural district in mid-Michigan. The school had adopted the *Saxon Math* curriculum and block scheduling of classes. Joyce's school district was facing many challenges. There had been a high administrator turnover rate, in terms of both superintendents and school principals, in recent years. A few years ago, the district's mathematics curriculum coordinator had succeeded in aligning the curricula between the elementary, middle, and high schools. Unfortunately, the district had to terminate her position and was never able to re-open it. As a result, Joyce explains, "To be real honest, in our building, things are pretty much a mess. And they're partly because our administration is not checking up on what teachers have been doing" (Joyce, Ninth Study Group Session). Due to a lack of guidance and coherence, Joyce reports that the mathematics teachers in her own building were implementing the Saxon curriculum at widely different rates, making it difficult for the

mathematics department to determine which students were ready for algebra. Fortunately, Joyce's school had decided to conduct a search for a new mathematics textbook. Thus, Joyce was especially interested in learning more about the document's vision and recommendations for the curriculum of middle grades mathematics. "Since our school is studying our current mathematics curriculum right now, this gives me the opportunity to really study what we are currently teaching in middle school and what we should be teaching at middle school and in the elementary and secondary levels" (Second Journal Entry).

Joyce set the following goals for improving her teaching: 1.) provide more real-world applications; 2.) help her students make mathematical connections; 3.) increase her students' interest and motivation in mathematics; and 4.) increase her students' ability to work independently, become better problem solvers, and use higher level thinking skills (Application, Question 3b). In her application to the study group, Joyce reported that she was somewhat familiar with the NCTM *Standards*. She had read portions of the middle grades chapter (Chapter 6) in *Principles and Standards* but had not participated in any professional development that addressed the document. Joyce wanted to better understand the document so that she and her colleagues could develop and improve their mathematics instructional goals and strategies.

Although I am familiar with the Michigan Curriculum Framework, it is easy to become focused on particular benchmarks, which are not being addressed and lose sight of the bigger picture. I would hope that this project would provide a means of clearly and deeply understanding our goals and responsibilities as middle school math teachers and the strategies for successfully reaching those goals. (Application, Question 4)

Like Janelle, Joyce was excited about the prospect of having opportunities to share and interact with other middle school mathematics teachers. "Sharing ideas with other middle

school teachers has always been one of the best resources I have found, but in our school we have very little time to share with each other” (Second Journal Entry).

In describing what she would expect to see in a middle school mathematics classroom that was aligned with the NCTM *Standards*, Joyce wrote:

There would be resources available to the teacher and students such as computers, dictionaries, maps and atlases, various types of manipulatives, and measuring devices. Everyone would be engaged in the lesson. Students would feel free to ask questions and would be encouraged to explore on their own with the necessary resources available to them. There would be guidance and direction, but not an “only the teacher knows” atmosphere. Students would question not only the current topic, but would be curious about extensions of the topic. The teacher would include all students in class discussions and activities. I would not expect to see a boring lecture, sleeping students, or many discipline problems. (Joyce, First Journal Entry)

In this description, Joyce characterizes a *Standards*-based classroom as one rich with instructional resources. Students are engaged, curious, and eager to learn. The teacher and students share authority in the classroom, with students encouraged to explore and ask questions.

### **What Ideas Did Joyce Develop about *Principles and Standards*?**

In this section, I discuss some of the key ideas that Joyce developed through her study of the document and participation in the study group. I begin by describing Joyce’s overall impressions of the document and the ways in which she envisioned using the document. Next, I trace her ideas about a central theme that arose from the document and that became salient to her, namely the importance of “slowing down” and spending more time developing concepts before pushing for algorithms. Finally, the section concludes with a summary of the impact the study group had on Joyce.

## Overall Impressions

Joyce was surprised to find that unlike other educational policies, *Principles and Standards* was straightforward and easy to read.

My first thought about the document is that it is “reader friendly”. I was pleasantly surprised at how easy it reads and how interesting it is. I really expected our reading assignments to be a chore – a task I would have to force myself to complete. This was not the case. The document is written for teachers - unlike some Department of Education literature we are expected to read and become familiar with, that ends up making me feel stupid. I could honestly tell another math teacher that reading the document would be worthwhile and even somewhat enjoyable. (Joyce, NCTM Homework Assignment)

Joyce found that studying the document with other colleagues was especially important because she was exposed to new ideas and perspectives. However, she did find that working with peers from different schools and districts could be challenging.

If one could read the document with a group of teachers, it would be even more worthwhile. Our discussions opened up many areas of thought and consideration that I would have missed had I just read by myself. Sometimes in our study group, we were limited by lack of knowledge of each other’s particular situations. But if other teachers were to begin a study group within their own district, it would be very beneficial. (Joyce, NCTM Homework Assignment)

In particular, Joyce felt “left out” at times because so many other teachers in the group were using the CMP curriculum, while she and her partner Monique were using *Saxon*, a curriculum that is not well aligned to *Principles and Standards*.<sup>1</sup>

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<sup>1</sup> See Hill (2001) for an analysis of *Saxon Math* and its incompatibility with the goals and visions of mathematics reform portrayed in documents like the NCTM *Standards*.

## Ways of Viewing the Document

Joyce's comments during the study group sessions and in her journal entries indicate that she came to the group with a very specific, clearly defined agenda – to use the experience as an opportunity to better understand what should be the learning goals for middle school mathematics curricula. In other words, Joyce primarily viewed the document through the lens of document as *curriculum map*, as a tool for analyzing, designing, and choosing mathematics curricula. For example, in her application to the project, Joyce stated that the following goals for joining the study group.

I am hoping to gain a clear understanding of NCTM's Principles and Standards. I believe that this can help me to develop instructional goals that would improve my teaching. Through collaboration with other middle school teachers, we could improve instructional strategies and motivational techniques and share ideas and concerns. Our middle school math department is currently looking for materials to "fill the gaps" that exist, to increase their interest and motivation, and to properly align with state benchmarks and standards. (Joyce, Application Question 4)

Joyce maintained this focus on how the document could help her think about curriculum throughout the project. For example, when asked to share overall reactions to the document, Joyce wrote:

It is very helpful to read about what students at various ages and levels of skill should be capable of doing and understanding. It very strongly suggests the need for aligning our math curriculum in our district. It was aligned about 3-4 years ago and since that time we lost our math coordinator. She was an excellent organizer and put a great deal of time and effort into aligning our curriculum, but since she has been gone, much of her work has gone by the wayside. I hope that through participating in this project, we can once again address that need in our district. I have already mentioned this to my building principal. (Joyce, Third Journal Entry)

Joyce sees the document's potential in helping her think about curriculum alignment and in analyzing her school's mathematics curriculum. She continued to reflect on her

schools' curriculum in light of the document's recommendations throughout the project. For example, in the introduction to Chapter 3, the document provides a visual representation of the level of emphasis each of the ten standards should receive across the four grade bands. This diagram highlights the document's stance that each standard should not receive the same emphasis within each grade band. For example, although each of the ten standards should be interwoven throughout the middle grades, the Writers recommend that the focus should be on algebra and geometry. Joyce referred to this diagram frequently, using it to analyze and draw conclusions about her own curriculum.

I think that our middle school students in the "normal" math classes are still spending too much time on the Number Standard. I keep referring back to the chart on page 30 that shows a large portion of our focus should be on algebra and geometry. Except for in our honors algebra classes, other students experience just a small introduction to algebra and not very much in geometry either. An area that we are lacking in altogether is probability. I ordered some materials that we as a department are going to incorporate into our classes. (Joyce, Sixth Journal Entry)

In this passage, Joyce examines her mathematics curriculum against the document's diagram and concludes that they are not aligned (dissonance). In particular, she decides that she and her colleagues are spending too much time on number and little to no time on algebra, geometry, and probability (dissonance). In response to this realization, she takes action and purchases probability materials to incorporate into her teaching (synthesis, experimentation). Joyce continued to reflect on curriculum and search for ways the document could assist her throughout the project. For example, in planning for our work during the summer meetings, Joyce requested that we spend some time preparing handouts summarizing our work that she could share with colleagues in her building and could use to inform their textbook selection process (Twelfth Study Group Session).



Although conceiving of the document as a curriculum map was most salient for Joyce, she also saw the document as having other purposes, such as serving as a lever for change. For example, she foresees using the document to help her incorporate more calculator use in her teaching.

This section of the reading [the Number Standard] also addressed students being able to decide what type of calculation is appropriate for a given problem. The text that we are currently using does not allow for the use of calculators and this is an issue that I have been struggling with. After reading this section, I feel that I can justify use of calculators at appropriate times and will begin to help students make those kinds of decisions on what type of calculation is necessary. (Joyce, Third Journal Entry)

In this journal entry, Joyce talks about using the document to justify the use of calculators in her classroom. Having such support was particularly important for her, as her mathematics curriculum (Saxon Mathematics) strongly discouraged calculator use. Thus, it seems Joyce sees the document as more compelling, or more respected, than the curriculum adopted by her school. Like Brian, Joyce also envisions using the document as a lever for change by encouraging other constituents to read the document. The following passage represents one question Joyce reported wanting to ask the Writers.

My first question involves the ideas put forth in Chapter 8. How do we facilitate changes within our schools/districts? I agree with the statements made by the writers concerning the necessary support and vision of administrators, teachers, parents, and community, but if that foundational knowledge (awareness) is not present then how do we make it a priority for others? In the conclusion of the document, it refers to Principles and Standards as a "catalyst" in reaching these goals. How do we convince others to take the time to read or at least become familiar with the document? We all know people (including administrators and teachers) who believe that mathematics education has not changed and that what worked back in the 50's should still work for students today. How do we overcome this obstacle? (Joyce, Seventh Journal Entry)

In this passage, Joyce considers how to use the document to convince others of necessary changes. Thus, she sees herself using the document to analyze and improve her mathematics curriculum, but she also feels compelled to “spread the word” and let others in the community know about the document and be willing to give it serious consideration.

In the next section, I present discussion and analysis of a key issue that became central to Joyce as she studied the document and participated in the study group – the notion of “slowing down” and spending more time on developing mathematical concepts. This issue has its roots in the recommendations put forth in the document, and in the teachers’ ensuing discussions. Through discussion of Joyce’s reactions to and developing ideas about this issue, I aim to characterize Joyce’s experience in the project, and to trace its impact on her beliefs, priorities, and classroom practice. This discussion will also highlight how Joyce’s study of the document and participation in the study group discussions helped her to move through at least three of the four stages of professional development – dissonance, synthesis, and experimentation.

### **“Slowing Down” and Spending More Time on Concepts**

One of the most important ideas that emerged for Joyce as she studied the document and participated in the study group was the notion of “slowing down” and allowing more time for concept development before pushing for students to master algorithms. Analyses of Joyce’s application to the project and early journal entries suggest that this was not initially a salient issue for her. For example, in describing her personal goals for participating in the study group, she made no mention of a desire to

better understand what relationship, if any, might exist between concept development and algorithms (Application, and Second Journal Entry). However, she does express concerns early on about her students' ability to compute and use algorithms. For example, during the second study group session, teachers were discussing the document's recommendation that, at certain times, teachers need to assume mastery and move on. Several of the teachers had argued that assuming mastery was necessary if they were to be able to teach students the big ideas of middle school mathematics. In particular, many of the teachers were in agreement with the document's stance that whole number computations should be mastered in elementary school. At one point during the discussion, Brian described the pressures he and other teachers in his district experienced from the community in terms of computation.

Brian: Right. But this is a very well educated community. These are leaders of industry, businesses and whatever, many of them college professors, were in the legislature, and these are the people that kind of make things run. And where are they? They're thinking that we need to teach computation. We've got this huge schism between what this is saying and what the public wants.

Joyce: Well, I want my kids to sit down and multiply and divide and add and subtract without my help. So, I don't... And, I'm kind of struggling with that right now with this low class that I have because we're still working on basic computation with these kids. And we're trying to do more than that, too, but if they can't do basic computations, then when we're trying to teach them area and perimeter, they're never going to come up with the right answer because they didn't add right or they didn't multiply right or something like that. So, what do we do? Do we get to a point where we just finally say they're just not going to be able to multiply two-digit or three-digit numbers? So, from this point on, because we've got to teach them these other things, we're just going to let them use calculators and that's ok? And that's a legitimate question to me. I don't know. Maybe that, do we reach a point where we do say that they're not going to be able to do pencil and paper, so we'll just go to a calculator and then still try to teach them these other concepts that they need to know?

Edgar: Or do we keep starting in September teaching two- and three-digit multiplication? (Second Study Group Session)

In this passage, Joyce disagrees with Brian, going out on a limb by aligning herself with Brian's community members and admitting that she, too, values computation. In addition, she admits "struggling" and not knowing what to do with students who still cannot compute with paper and pencil. Underlying this discussion is a consideration of which alternative is more equitable for students – ensuring they know the algorithms, or ensuring they get to move on to more advanced mathematics.

After this initial discussion of assuming mastery and moving on, and the relationship to equity, Joyce reported that she began to experiment with her teaching, by testing some new approaches that she encountered in her reading of the document (synthesis and experimentation). For example, to address her students' struggles to solve linear equations in one variable with mixed number coefficients, Joyce decided to try to "slow down" and encourage students to take their time and talk through the problem with her. She then asked them to try to find reasonable estimates to the answer, shifting the focus from following the algorithm correctly and computing the answer to understanding what the equation represented and what it meant to solve an equation.

In my own classroom, I have already used some of the suggestions [from the document] in my teaching. Today in class, we were solving an equation of the form  $ax + b = c$ , where  $a$ ,  $b$ , and  $c$  are mixed numbers. Students have been struggling with these problems, not knowing whether to add or subtract for the first step (and which numbers to use) and then when dividing which number is the divisor. We began today by looking at the original problem, talking about what we were trying to find, checking out possible solutions by substituting whole number values for  $x$ , thus finding a reasonable estimate ( $x$  is between one and two). Not until then did we actually begin to solve the problem. I think that what we did fit in with the section on making reasonable estimates. The reading talked about students in grades 6-8 who were unable to estimate  $12/13 + 7/8$ . That's kind of scary! I'm afraid that sometimes we feel so driven to reach a goal

by the end of the year that we miss some of these basic skills that we just assume students have accomplished. Today (I hope) I slowed down just a little to try to work on one of those key areas. (Joyce, Third Journal Entry)

In this passage, we see Joyce describing how she drew on the document's ideas about the importance of making reasonable estimates to solve problems to experiment with some new approaches to her teaching. Joyce also shared this new perspective on the value of "slowing down" with her study group colleagues in the fourth session.

Monique: Joyce and I were just talking about that on our way here. That some of our students were working on the, two halves  $x$  plus one-third equals, you know. And they'll be like, "Okay, do I add or subtract? Which one do I flip? Do I have to make it...? And they don't even care. I mean, it's not even like they really understand the process. They just want to know the steps and they just want to do it. They don't *want* to understand it. Joyce was saying that she tried to go through and I'm like estimate and she thought that they got it. But my honors kids were just like, "We don't even care. Just tell us what to do so we can do it."

Dawn: Where does that come from?

Tim: Parents

Brian: Previous experience

Someone: Experience in schools

Joyce: Well, I think that's how we've taught it. One of the things that I read that really, today because we've been trying to work on these equations forever. And, still, the kids, like I was saying, twenty days in a row this same kid comes up to me and asks me the same question. Do I add or subtract, and which ones do I flip? And I'm like, uh! So, today we just started out and we just wrote the equation. And we just started trying to analyze it. You know, what are we really looking here for? What is this  $x$ ? What is it that we're supposed to be finding? And we just kind of went through it step by step. And then we just started making estimates. I said, "Let's, you know, would this work if  $x$  was equal to one? We'll just try whole numbers. What would this side of the equation be equal to if we put 1 in for  $x$ ?" And they said, "Well, around five." And I said, well, okay. What if  $x$  was two? Well, then it would be around eight. Well, what is the answer supposed to be? Like six and seven-eighths. So, what does that tell you? Well, it's got to be between one and two. So, we just started kind of taking it apart and doing it slowly like that. And, you know, so that when

they got to the end, they knew that if they came up with twenty-one thirtieths, that somewhere they made a mistake. You know, they flipped the wrong one or something.

Dawn: Right.

Joyce: But at least they would know, but whether they'll do that on their own is doubtful. But maybe if we at least try to take the time to do that... *Because quite honestly, for myself, I think I've been just teaching the algorithm. You know, how to do it, because I learned it that way. It was okay for me. But for them, I don't really think it is. And, as I read this, it just really made me stop and think that, you know, that that's something I don't think that I've done right. Maybe I need to start going slower with this and trying to get them just to the concept of it and then the algorithm will follow.* [italics added] (Fourth Study Group Session)

In this passage, Joyce comes to a realization about her own practice, recognizing that in the past she had just been teaching the algorithms (dissonance, synthesis). She now wonders if that has been the right thing to do, and considers that this technique of slowing down and allowing students time to make sense of a problem for themselves might have some merit. Thus, her experimentation in her classroom comes full circle, and she begins to gain new insights into and awareness of her beliefs and practice.

Moreover, Joyce later begins to question her original stance on assuming mastery and moving on. Recall that during the second study group session, Joyce argued against assuming students had mastered computation. She revisits this idea in a later journal entry.

Because so many of our students do not seem to have mastered many of the skills in the number standard, we seem to be caught up trying to teach those skills over and over again. I am really curious to see if we can continue on with algebraic skills and concepts by allowing our students the use of calculators. It seems that, at least from my experience, those students who are lacking basic number skills when they enter eighth grade are still struggling when they leave eighth grade. Maybe we do reach a point when we need to continue on with more challenging concepts for all of our students and hope that those basic skills will eventually be mastered. We must also recognize that very few of us actually work out a

long division problem by hand in the real world and it will be no different for our students. I do not believe that calculators are the answer for all of our problems, but I am hopeful that they will allow us to teach what is important for students in seventh and eighth grades. (Joyce, Sixth Journal Entry)

In this journal entry we see Joyce reconsidering her original stance on the idea of assuming mastery and moving on. She now seems more open to considering it, admitting that, “Maybe we do reach a point when we need to continue on with more challenging concepts for all of our students”. She begins to frame some arguments for herself as to why assuming students have mastered basic skills by eighth grade might be appropriate.

### **Summary: Impact on Joyce**

What can be said about the impact of Joyce’s participation in the study group and analysis of the document on her beliefs, priorities, and practice? First, Joyce became more knowledgeable about her own middle school curriculum, and of the middle school curriculum proposed in *Principles and Standards*. She began to see that her current curriculum places too much emphasis on number and not nearly enough on algebra, geometry, and probability. Consequently, she takes it upon herself to purchase new materials that will enable her and her colleagues to incorporate probability into their instruction. She has also found a tool for curriculum analysis in the document, recognizing how it will help her and her colleagues when they begin to consider adopting a new textbook. Thus, in just the realm of curriculum, we see how the document can serve dual purposes. In the first example, Joyce’s deepening understanding of the vision of curriculum put forth in the document catalyzes her to make some changes to her own curriculum. In the second, Joyce’s deepening understanding of the document enables her

to see the document as a tool that can support her in making changes she was already intending.

Second, Joyce became more explicit about her beliefs. For example, she began to question her stance on the importance of computation, especially in insisting that students master computation before they can be exposed to more advanced mathematical ideas. Although it is not clear yet that Joyce will lessen her expectations for students' mastery of computational algorithms, she at least has some new perspectives to consider, and a willingness to entertain them. Third, Joyce became more explicit about her current classroom practice, realizing that in the past she has had students focus solely on the algorithms. She begins to feel dissatisfied with this stance and considers an alternative approach. Eventually, Joyce begins to experiment with some changes to her teaching by letting her students, and herself, slow down and explore mathematical problems before rushing to the algorithms.

In terms of Ross and Regan's (1993) model, we see Joyce entering three of the four stages of professional learning. First, she experiences some dissonance. She becomes more explicit about her own beliefs and practice, and she senses some dissatisfaction with her current ways, in light of the new ideas that the document provides. In considering the document's recommendations and then adapting them to develop a new approach that might better support her students in solving one-variable linear equations, she engages in synthesis. Finally, Joyce adopts some short-term behavioral changes, piloting some of her new ideas, such as "slowing down" in her classroom, thereby engaging in experimentation. Whether Joyce will move to integration, by developing further



adaptations and internalizing her new ideas and strategies for the long-term, remains unclear.

In the next (and final) chapter, I summarize the findings from this study, and proposing some new hypotheses generated by these findings. I then present a few of the limitations of this study. The chapter concludes with some recommendations for future professional development, future policy development, and future research.

## CHAPTER 8

### CONCLUSION AND RECOMMENDATIONS

In this chapter, I begin by summarizing the findings from this study, and proposing some new hypotheses generated by these findings. I then present a few of the limitations of this study. The chapter concludes with some recommendations for future professional development, future policy development, and future research.

#### Summary of Findings

In this discussion, I summarize the findings from this study. In doing so, I will draw primarily on the data presented in Chapter 4 and on the three case studies presented in Chapters 5 through 7, although I will occasionally bring in additional data that has not been discussed elsewhere. As I summarize the findings of this study, I will propose some hypotheses to help explain them.

**Finding 1: Teachers viewed the document from different “lenses”, and individual teachers often viewed the document from multiple lenses.**

Analyses of the ways in which teachers viewed the document revealed that teachers in the study group viewed the document from a range of “lenses”. Five possible perspectives emerged from the data. First, teachers saw themselves using the document as a *warrant* to defend their current beliefs or classroom practices. In particular, many teachers anticipated how the document’s stance on technology could be used to defend

their use (or non-use) of calculators and other instructional technologies in the classroom. Second, teachers viewed the document as a potential *lever for change*. They envisioned how they might use the document to lobby to administrators and other teachers for changes they desired. Underlying both of these views – document as warrant and document as lever – is an assumption that the document carries with it the influence and authority to make others take notice and abide. Third, teachers saw the document as a *tool for their own learning*. Several teachers saw its potential as a tool for analyzing their own practice. Others saw it as intentionally provocative and radical at times, in order to “push” the readers’ thinking. Thus, teachers saw *Principles and Standards* not only as something they could learn *about*, but also *from*. Fourth, teachers viewed the document as *a springboard for conversations* among teachers and others invested in mathematics education. They saw the document as providing rich fodder for catalyzing productive and meaningful discussions. Some teachers suggested that the document represented a “safe” or neutral site, thereby enabling and supporting these conversations. Fifth, teachers viewed the document as a *curriculum map*. They saw how the document could assist them in analyzing their own curriculum or in designing or choosing a new one. Given the wide diversity in the group in terms of certification, teaching experience, mathematics curriculum, school context, and initial awareness of the NCTM *Standards*, it seems probable that these multiple views are not a phenomenon of this particular group of teachers. That is, I would expect similar views to emerge from a different group of teachers with the same range of diversity.

Moreover, individual teachers exhibited the capacity to view the document from multiple lenses. For example, Brian anticipated using the document not only as a warrant,

but also as a lever for change and as a tool for his own learning. Janelle viewed the document as both a tool for her own learning and as a curriculum map; Joyce saw in the document its potential to be used as a curriculum map and a lever for change. Thus, the teachers seemed to see the document as dynamic, as multi-faceted and multi-purposed. This validates the Writers' claims in Chapter 1 that the document can serve achieve multiple functions (NCTM, 2000, p. 6).

What is also interesting is what views did *not* emerge from the data. In particular, it is important to note that teachers did not seem to view the document as a mandate from above. They did not feel as if they were expected to agree with and dutifully implement every recommendation put forth in the document. Of course, I tried my best to encourage this. Whenever possible, I pushed the teachers to question and critique the document's messages and recommendations, and I assured them that the goal of the professional development project was not to "convert" them. However, I suspect that my influence was not the driving factor. Rather, I hypothesize that it is the way in which the document is written that enabled teachers to see it more as a guide and a platform for discussions than as a directive or mandate. In particular, teachers referred to the document being reader-friendly and engaging. They enjoyed the inclusion of the mathematics tasks and vignettes. They especially appreciated the frequent calls for teachers to have increased opportunities for high-quality professional development. In sum, teachers reported that they felt the document was respectful and supportive of them. These are not qualities of dictates.

What else might we learn from the emergence of these multiple views of the document? On the one hand, nothing is particularly surprising about the views conveyed

by this group of teachers. For example, I discussed in Chapter 4 why it was sensible for teachers to assume the document possessed some authority and thus could be used as a warrant for current beliefs and practices or as a lever for effecting change. Furthermore, given that the document presents a Curriculum Principle, and given that it carefully specifies the mathematical content and process students should learn from kindergarten through grade twelve, it makes sense that the teachers would see the document's potential as a tool for analyzing mathematics curricula and determining appropriate learning goals.

On the other hand, some interesting hypotheses can be generated upon taking a deeper look at these findings and asking, "What might these views tell us?" Let me begin with the views of the document as a warrant and as a lever. As I attended the study group sessions and read teachers' journals, I was struck by how frequently teachers spoke of using the document to either defend what they already believed or were doing, or to lobby for things they wanted to be doing. Why was this so important to them? It seemed that these teachers were in need of, and intentionally on the lookout for, something they could use to defend themselves. After all, why would they contemplate using the document as a warrant if they did not feel they needed defending? And why would they see the document as a potential lever for change if they did not feel they needed assistance in effecting changes? I hypothesize that the teachers' inclination to see the document in these ways is in part a function of today's political climate, in which talk about teacher accountability, national standards, and "high stakes" testing abound, and in which teachers' knowledge and competence are constantly being called into question in the media. Given this state of affairs, it makes sense that teachers would be feeling

uneasy and threatened and in need of defense. Given their competence is often in question, it makes sense that they might feel the need to have the backing of a national document that had been developed and approved by “experts”. On the other hand, perhaps these larger trends and attitudes are too far removed to really affect the disposition of the typical teacher. But for at least three of the teachers – Brian, Mindy, and Kayla – these trends and attitudes had seeped into their backyards. Brian, Mindy, and Kayla each shared stories of the difficulties they faced in their school districts, primarily from parents who were wary of, if not adamantly against, the use of the CMP curriculum in their schools, with their children. These teachers had witnessed their schools being attacked in the local newspapers and had attended volatile school board meetings.<sup>1</sup> Thus, at least for these three teachers, it makes sense that they would feel a need for, and be inclined to, view the document in terms of its ability to defend their practices and to help them lobby for changes. In other words, these teachers’ ways of viewing the document seem linked to their local contexts. This leads me to the next finding.

**Finding 2: The ways in which particular teachers viewed the document were related to the demands, priorities, and characteristics of their local contexts.**

In this section, I argue that the ways in which individual teachers viewed the document are not haphazard. Rather, their views of the document seem to be connected to characteristics of their local contexts. These findings contribute to those of the R<sup>3</sup>M researchers, who reported an alignment between a site’s choice of reform emphasis and its contextual features.

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<sup>1</sup> In fact, Kayla reported that at one point, she “took on” these attacks herself in the local newspaper (Second Study Group Session).

First, consider Brian. Brian exhibited multiple views of the document, but he tended to focus primarily on its potential to serve as a warrant, a lever for change, and a tool for his learning. In the section above I argued that his tendency to view the document as a warrant and a lever might stem from the situation in his local context. Brian taught in a very affluent school district. His students' parents tended to be highly educated professionals. Many of these parents, in addition to other community members, were vehemently against the use of the CMP curriculum with their children. They did not understand or agree with the curriculum's philosophy of school mathematics and of how students learn mathematics. They were especially worried about their students' readiness to take honors and advanced placement courses in high school, so that they would be in a position to compete for openings in the most prestigious universities. These parents and community members were very vocal about their disapproval of CMP, and had the backing of some of the mathematicians at the local university. (Some of the parents were mathematicians themselves.) In addition, the only other middle school in Brian's district – the “sister” school to his school – was also not supportive of CMP. Although they were supposed to adopt it, they continued to use more traditional materials “behind the scenes”. Consequently, Brian, who was an advocate of CMP, was always on the lookout for possible attacks. He felt that the curriculum was constantly in jeopardy; at any minute, it could be pulled from his school and replaced with a more traditional series. Given this context, it makes sense that he would see *Principles and Standards* in terms of its potential to offer him some “ammunition”, both on the defensive and on the offensive.

What might explain Brian's inclination to see the document as a tool for learning? First, recall that he primarily envisioned how the document could be used to support the

learning of *others*, particularly elementary school teachers. This is not coincidental. Brian was aware of problems his district was facing in terms of pushing their elementary schools to strengthen their mathematics program. Committed to the CMP program, Brian needed the teachers that came before him to get his future students to a certain place mathematically, so that they were ready to take full advantage of CMP. In other words, he was cognizant that his success as a teacher was highly dependent on what the teachers in grades three through five accomplished with his future students. Although this is probably true of all teachers, regardless of curriculum, this is especially critical for curricula such as CMP, which propose very ambitious mathematical learning goals for students. Brian was cognizant of all of this, and thus in search of ways to support the elementary school teachers in his district. Thus, it is not surprising that he envisioned using the document in this way.

How might characteristics of Janelle's local context help explain how she came to view the document? Recall that Janelle primarily viewed the document as a tool for her own learning. In particular, it served as a tool for analyzing her own practice, by making her aware of new approaches and perspectives, and by providing her with rich tasks to experiment with in her classroom. Janelle took full advantage of these resources, posing several of the tasks with her own students, and using them as a site for investigating new instructional approaches. She became especially intrigued by and committed to the "explore first, algorithms second" approach, gradually modifying her practice to include more of this.

Why might Janelle have taken this approach? I propose two influential factors. First, it fit with her disposition and philosophy. Janelle viewed herself as an



“intellectually curious” lifelong learner, eager to explore ways to make her teaching more effective. She had come to a place in her life where she was confident in her teaching and in herself as a person, and thus was rarely threatened or insulted by criticisms posed by others. Second, I argue that Janelle’s context allowed her the freedom to be herself and experiment with changes to her teaching. In particular, the fact that her school had no set mathematics curriculum meant she was able to design her own learning experiences for students, and this gave her a great deal of freedom to experiment with new instructional techniques. She also taught in a self-contained classroom, which meant that she was able to spend as much time as she wanted on her mathematics lessons. In addition, Janelle reports that her administration and students’ parents seemed to really trust and respect her; she rarely felt that her competence was in question. In fact, the other teachers in the study group were aware of Janelle’s special circumstances, and occasionally mentioned these factors to at times dismiss Janelle’s ideas, arguing that they did not have similar freedoms to do as she did. Thus, it seems that even the other teachers saw Janelle’s tendency to treat the document as a site for her own learning as a function of the particulars of her local context.

Perhaps these same characteristics of Janelle’s local context might also help explain why she did *not* envision using the document as a warrant or as a lever for change. Respected and trusted by her principal and by her students’ parents, and free to design her own mathematics curriculum, Janelle did not feel the need to search out ways to defend her beliefs or practices. Similarly, she did not feel the need for “ammunition” to effect the changes she desired. Viewed as a professional, both by herself and by her community, she was free to adapt her instruction in the ways she felt were most

appropriate. In order to improve her teaching, she needed to learn more in order to make wise choices, not anticipate ways to defend these choices. As such, she turned to the document as a tool to guide her learning about what changes she might make, rather than as a warrant or lever for the changes.

Janelle's view of the document as a curriculum map can also be explained in terms of features of her local context. As I have discussed above, Janelle's school had not adopted a particular mathematics curriculum. Their only guidelines came from a curriculum framework that Janelle brought with her from another school district. However, at the time of the study, Janelle and her colleagues were in the process of analyzing this framework and considering adopting a curriculum series. Thus, issues of curriculum were a priority for Janelle that year. She often asked the other teachers in the study group about the curricula they used, as well as broader questions about what a curriculum should be.<sup>2</sup> She reported that she and her colleagues were in search of any guidance or support they could find that would assist them in this process. Hence, it makes sense that she would turn to the document as one potential source of guidance.

Like Janelle, Joyce and her colleagues were also in the process of rethinking their mathematics curriculum. Thus, it makes sense that Joyce would come to the project motivated to find ways to support their work. In this way, characteristics of Joyce's local context help explain her inclination to view the document as a curriculum map. But Joyce also viewed the document as a lever for change, and this, too, can in part be explained by the realities of her local context. Recall that Joyce's school had adopted the *Saxon Math*

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<sup>2</sup> For example, Janelle was especially concerned about how rigid a curriculum needed to be, in terms of expecting all teachers to cover a certain amount of material in a certain amount of time.

curriculum, and that her school district had experienced a high rate of administrator turnover in the past few years. Although Joyce and her partner Monique gradually became more and more dissatisfied with their curriculum, they report that many teachers in their building were supportive of *Saxon Math*. In addition, there were concerns about curriculum alignment – different mathematics teachers were covering widely different amounts and kinds of content over the school year. In other words, Joyce’s local context was characterized by instability and tension. Given this situation, Joyce felt the need for some authority that would support her in the changes she was considering making, such as incorporating calculators into her instruction (something her textbook forbade). Moreover, it makes sense that she would see in the document the potential to speak to administrators and other teachers in her school and district and convince them of the changes Joyce envisioned. Thus, Joyce’s view of the document as a potential lever for change also seem connected to particular features of her local context.

**Finding 3: Teachers found the work of studying and discussing the document to be meaningful and engaging. However, they need support in managing and maintaining productive discussions around the document.**

Analyses of the teachers’ study group discussions reveal that teachers were quite engaged in the work of making sense of the document’s vision and recommendations, and they found such work meaningful. One source of evidence for this is simply the teachers’ ability and willingness to participate in the study group discussions that occurred in the evenings, after school, for three hours or more at a time. Although teachers were receiving monetary stipends for this work, it quickly became clear that this was not the motivating factor for most teachers. First, we often stayed much later than the

scheduled three-hour time block, and I often had to forcefully interrupt the teachers' conversations in order to close the session. Second, the teachers did a great deal of supporting work outside of the study group sessions on their own time – reading the document, maintaining journal entries, working on mathematics tasks, engaging in lesson study with their partners. Third, attendance at the study group sessions was near perfect. Fourth, it was the teachers who came to me and requested that we continue meeting into the summer, and they were not at all concerned if there was no money available to support this work.

Another measure of the teachers' commitment to this type of work and its significance to them was their interest in and willingness to “spread the word” about the document to other teachers. Some of this stemmed from their interest in using the document as a lever for change. However, this inclination to want to “get the word out” seemed to extend beyond desires to effect the particular changes they were most interested in. Rather, teachers in this study group exhibited a genuine interest in telling other teachers, both in middle school and in other grade bands, about their reactions to the document in the hope of encouraging them to study the document themselves. For example, the teachers spent a great deal of time, both in the study group sessions and later on their own time outside of the study group sessions, developing the lists of “Big Ideas” for each standard that they read.<sup>3</sup> One of their primary motivations for engaging in this work was they envisioned distributing the Big Ideas to their colleagues and using them to communicate about the document with others. Another example is the teachers'

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<sup>3</sup> In fact, the summer group thought this work was so important that, in the interest of time, they volunteered to work alone, outside of the study group sessions, on particular standards so that a complete set of Big Ideas would be developed.

enthusiasm for submitting proposals to the NCTM annual conference, both in 2002 and again in 2003, to share their work in the study group. Eager to “spread the word” on a national level, the teachers were willing to meet several times after the study group had disbanded to plan these sessions.<sup>4</sup> Most of the teachers had never attended an NCTM annual meeting, and none of them had ever given a conference presentation before; thus, they were quite nervous about the prospect of a public presentation in front of a national audience. However, eleven of the original fourteen study group members accompanied me to the 2002 meeting and took an active role in the presentation by running small working groups in the audience.

Although teachers were very engaged in their work in the study group and seemed to find such work meaningful, analyses of the level of cognitive demand of the teachers’ discussions reveal that teachers struggled to maintain the level of cognitive demand during the discussions. For example, only about one-fourth of the discussions that began at a high level of cognitive demand were maintained at this level; the remaining conversations included significant portions of low-level talk. While somewhat discouraging, these results are not entirely surprising. Maintaining a discussion at a high level of cognitive demand around complicated issues of teaching and learning, within a diverse group of teachers of varying experience levels and priorities who, at least in the beginning sessions, barely knew each other should be difficult! Add to this the fact that these were evening, weekday sessions and it is impressive that teachers were able to generate the level of discussion that they did.

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<sup>4</sup> Teachers were not paid for this work.

What this suggests is that teachers needed more support from me in managing and maintaining productive discussions around the document. Looking back, I can identify two primary reasons for my failure to do a better job at supporting the teachers in maintaining discussions at a high level of cognitive demand. First, I was very wary of being seen as the expert in the group for I felt that such a perspective, if taken too far, would in effect shut down the teachers' conversations. Related to this, I knew I needed to give teachers time to feel safe and comfortable making their ideas public in the study group, and I worried that by stepping in too soon, I might intimidate them and make them more reticent to share their ideas. In addition, I wanted the teachers to share ownership in the study group, and feel they had a voice in its direction and goals. For these reasons, I was hesitant to step in too often or too soon, and tried, especially in the early sessions, to leave the discussions in the hands of the teachers. Second, due to Brian and Mindy's success at leading the second study group session (the first session in which teachers discussed the document), I mistakenly assumed that the remaining teacher-teams would be equally able to facilitate substantive discussions around the document. This was not the case. Several of the teacher-teams struggled to find ways to initiate discussions, and often resorted to posing low-level questions. In these cases, the other teachers, perhaps out of respect to the leaders of the session, seemed reticent to step in and take over the discussion. It was at times like these that I should have been more proactive. The teachers needed me to model good questioning around the document, just as Janelle needed to see me model good questioning in her classroom. I also needed to help the teachers make the characteristics of our productive discussions more explicit, to communicate to them the types of discussions we should be aiming for. Thus, in retrospect, I should have done a

better job of finding ways to model what “good” discussions look like, and I should have helped teachers become more explicit about the goals of our conversations.

**Finding 4: This experience – studying the document within the context of a study group consisting of a diverse group of teachers – was not appropriate for all teachers.**

The reader with an eye for details might be wondering, “What happened to Suzy?” In this section, I briefly discuss Suzy’s experience in the study group and use it to argue that this project was not particularly educative for teachers like Suzy who were just beginning their careers.

Suzy was Dara’s school-based partner in the project. The year of the study was Suzy’s first year teaching. She had interned in a kindergarten classroom and was now teaching sixth grade mathematics. Suzy, Dara, and the other teachers at their school were participating in a curriculum-mapping project in which they were attempting to align their curriculum to the state’s framework. Through this work, she had become very knowledgeable of the state’s framework; however, she described her knowledge of *Principles and Standards* as “minimal” (Application, Question 2). Consequently, one of Suzy’s motivations for participating in the study group was to learn more about *Principles and Standards* in hopes that it could support their curriculum work. In addition, she hoped that participating in the study group would help her to become a better mathematics teacher (Second Journal Entry). In particular, Suzy wanted to learn more about the document so that she could “implement” them in her daily lesson plans. She was also excited about the prospect of learning from a group of more experienced mathematics teachers (Application, Questions 3a and 4).

Unfortunately, Suzy rarely participated in the study group discussions, and so it is difficult to determine what ideas she developed through her study of the document. One measure of her participation is the number of turns she took in the study group discussions.<sup>5</sup> In contrast to Brian who took the most turns (approximately 1300 turns, after eliminating turns in his journal entries, NCTM homework assignment, interview, and listserv discussions), Suzy took only 16 turns, the least of all teachers in the group.<sup>6</sup> Furthermore, the turns she took are of a particular nature – when asked, she described her lesson study project with Dara, she shared her way of solving the math tasks we worked on as a group, and she discussed what geometry topics were taught in their curriculum. In other words, she very rarely shared her reactions to or ideas about the document publicly. Suzy did complete six of the eight journal entries I assigned, and these provide some data on how she was thinking about the document. For example, she talked about struggling to negotiate the document's stance on technology. Were calculators to be readily available at all times or not? She also reflected on her use of lectures in her mathematics instruction, eventually deciding that she depended on lecturing too regularly and vowing to pose more open-ended questions and design more lessons that allowed students to explore and discuss mathematics (Third and Sixth Journal Entries).

I must admit that from the outset of the study, I was concerned about Suzy and what she might gain from participating in the project. On the one hand, I thought that perhaps this experience would be exhilarating for a first-year teacher. Being exposed to so many new ideas, and having the benefit of gaining insights and wisdom from more

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<sup>5</sup> This measure was easily attainable from the N5 database I developed.

<sup>6</sup> In contrast, the next lowest number of turns was 160.



experienced teachers, might give teachers like Suzy an incredible “boost” professionally. On the other hand, typical first year teachers are primarily concerned with “survival” issues like classroom management. I wondered how ready Suzy would be to take on issues such as the role of equity in mathematics education or the development of algebra across the grade bands. I also wondered if she would be at a disadvantage, in not having sufficient past experiences to draw on in making sense of the document. She might even feel too intimidated to share her newly formed ideas with a group of teachers she viewed as more experienced.

It seems that some of these factors did play a role in Suzy’s lack of participation. Indeed, Suzy was quite aware of her role as “listener only” in the study group, and attributed it in part to her focus on classroom management issues. “I felt that because this was my 1<sup>st</sup> year I was more concerned with my classroom management and discipline procedures. I feel that next year I will be able to concentrate more on math and my teaching it” (Sixth Journal Entry). She also attributed her lack of participation to the fact that she had little teaching experience to draw on during the study group discussions. Although Suzy recognized this, she still felt she had been able to learn a great deal by listening in on the teachers’ discussions.

I feel that I do not have a lot of input to the group because of my lack of experience with mathematics, but I know that I am gaining knowledge about lots of different areas. I like learning about the CMP curriculum, because I would like to try more of that style of teaching in my own classroom. I know that I have benefited as a teacher from participating in this project and I feel that I have had an opportunity to help my students become better math students because I have taken what I have learned and used it in the classroom. I have been conscious about asking my students why they have the answer that they have instead of just saying yup, that’s right. (Suzy, Feedback, Question 4)

Suzy's comments about her opportunities to learn from the group are encouraging. However, the data is insufficient and thus I cannot make any claims about the impact of the experience on Suzy.

Moreover, it is not clear if the changes she reports are due to her study of the document, or are simply a function of sitting in on discussions with other teachers. In other words, how meaningful were the readings from *Principles and Standards* for Suzy? The evidence I do have indicates that it was not the discussions of the document, but the supporting study group activities, that Suzy found most helpful. For example, in response to my solicitation for mid-project feedback, Suzy wrote:

I feel that the problems [mathematics tasks] we try and talk about help me the most. I like to be able to relate it to the classroom. I feel that it is meaningful to me. I really liked the case study that we read and discussed (percents, fractions, and decimals) because it related to what I am going to be doing in class next week. I am also excited about going to the computer lab next week to check out the e-examples. I think that I will benefit from this. (Feedback, Question 1)

For Suzy, our work on mathematics tasks, our discussion of teaching cases, and our exploration of the electronic examples were most useful and interesting to her because they were things she could "relate" to her own classroom. I interpret her statement to mean that these are activities that are most directly "importable" into her classroom. For example, the mathematics tasks we worked on as a group focused on middle school mathematics content. Thus, they were suitable for middle school students, and so if she chose, Suzy could take those tasks and use them directly with her students. Similarly, the electronic examples were available on the Internet for anyone to explore or use, and so once again, these represented activities she could use in her classroom. This preference for activities fits with the goals she stated on her application – to improve her teaching by

taking ideas from the document and “implementing” them in her classroom. Thus, it seems that Suzy might have found the study group experience equally as valuable if it had consisted solely of work on the activities she mentioned above, without any discussion of the document.

I suppose that future projects like this one could be designed to incorporate additional activities that center on classroom “records of practice” in order to be more responsive to the needs of beginning teachers. In fact, even experienced teachers like Carla occasionally requested that we spend more time in the study group thinking about how the document’s ideas and recommendations might play out in actual mathematics lessons. However, even with additional activities incorporated, I posit that there is a level of readiness needed before teachers are capable of finding a collaborative discussion of a document like *Principles and Standards* meaningful. Such readiness would include a certain level of teaching experience, of experience with students and schools and mathematics curricula, so that teachers would have enough to draw on and connect to when considering the ideas put forth in the document. Such readiness would also include a certain confidence in or comfort with one’s current mathematics instruction to be ready to move beyond issues of how to manage a classroom full of students and which activities to use. Perhaps a better word would be a level of *stability* in one’s teaching, where the “basics” of instruction are in place and teachers are ready to push themselves to the next level. It is difficult to reflect on and consider revising something that is not yet fully developed. Debbie Meier’s classic analogy of trying to change the tires on a moving car seems appropriate here (see Little, 1993, p. 140). This is not to say that teachers come to a point, with enough experience, that their teaching ceases to change or grow.

However, I would argue that the practice of beginning teachers is particularly unstable and in flux. Until their practice becomes more developed and defined, it seems that collaborative discussions of the nature that occurred in my study group are unlikely to be of much value. Indeed, Suzy seemed to struggle to find meaning in our discussions:

I like reading the Principles and Standards, but sometimes I feel like we sit and discuss for too long of a time period. I feel that it is more beneficial to do problems and hands-on activities along with the discussion. I think it makes it more meaningful. Also I am a go-getter type of person so I like to be doing things, rather than sitting for three hours discussing. (Suzy, Feedback, Question 2)

I conclude this section with a caveat. I do not mean to argue that the document has *nothing* to offer to new teachers. Perhaps receiving an overview to the document in a workshop would help them develop a sense of the direction in which they might want to develop their teaching. Or, perhaps a different type of experience in which they were to focus deeply on a small piece of the document, say the Algebra Standard, and work on developing their instruction around that content might be meaningful to novice teachers. What I am arguing is that the particular experience I designed in this study, in which teachers engaged in extended discussions around the “big ideas” put forth in the document, does not seem well suited for beginning mathematics teachers.

**Finding 5: The document is *generative* – it can stimulate rich conversations among teachers, and such conversations are fruitful sites for teachers’ learning.**

Finally, results from this study indicate that *Principles and Standards* is *generative*. The document stimulated rich conversations among the teachers in the study group, and such conversations, and the ideas they engendered, served as fruitful sites for teachers’ learning. This generative power of the document is evidenced in several ways.

First, as I discussed earlier, teachers had little trouble initiating and maintaining lively discussions of the document for hours at a time, indicating the document's potential to catalyze teachers' conversations. Moreover, teachers were cognizant of this potential, evidenced in their ability to envision the document as a springboard for discussions. In particular, teachers' comments reveal that they viewed *Principles and Standards* not as a static document consisting of a set of fixed recommendations to be implemented, but as a living document that can generate conversations among teachers about how the document's ideas and vision make sense in their local contexts. For example, Kayla discussed how the document had been used in her district as a neutral starting point that shifted conversations away from finger pointing and toward discussions of what the document's ideas meant for their district and their students. Callie saw the document as providing the "fodder" or ingredients for productive discussions, and that such discussions were a necessary component of making sense of the document and learning from the experience. Mimi saw the six guiding Principles as particularly generative of substantive conversations among groups of teachers, and was convinced that these conversations would be supportive of teachers' learning.

Results from the analyses of teachers' discussions in terms of the level of cognitive demand, presented in Chapter 4, serve as another source of evidence of the generative nature of the document. These analyses revealed that the vast majority of the central themes taken up by teachers were at a high level of cognitive demand and were either catalyzed by or supported by references to the document. In other words, the majority of the teachers' discussions of the document centered around complex, substantive issues that stemmed directly or indirectly from particular passages in the

document. Moreover, the majority of teachers' discussions of these substantive central themes included at least some significant portions of high cognitive demand talk. That is, the teachers not only initiated substantive issues for discussion, but also managed to develop and engage in some high level talk around the majority of these issues. Finally, analyses revealed that one-turn episodes were rare, indicating that teachers tended to build on each other's ideas during the study group discussions.

Finally, the educative potential of the document and of the discussions it catalyzes is evidenced in the impact participating in the study group had on Brian, Janelle, and Joyce. For Brian, reading and discussing the document helped him become more explicit about and dissatisfied with his (non-) use of technology in his practice, and catalyzed him to develop ways to incorporate more technology by designing and implementing web-based lesson plans. The experience also seems to have played some role in pushing him to a new stage in his professional career, namely becoming a teacher leader in his school and district. For Janelle, reading and discussing the document helped her become more explicit about a component of her practice, namely her tendency to provide students with algorithms for solving problems at the outset. Her readings and the surrounding discussions catalyzed her to consider and experiment with the "explore first, algorithms second" approach, gradually becoming more and more invested in it. For Joyce, reading and discussing the document helped her become more explicit about her beliefs, her practice, and her curriculum. She began to question her stance on the importance of computation, and she grew dissatisfied with her overemphasis on algorithms. As a result, she began to experiment with a new instructional approach by slowing down and providing her students with more time to make sense of the mathematics.

### Limitations of the Study

In this section, I discuss two limitations of this study. First, the research participants were volunteers. Thus, it is possible that the group of teachers that participated in this study possess special qualities not characteristic of the general population of middle school mathematics teachers. For example, by self-selecting themselves into this study, it is possible that the teachers in this study were stronger advocates of the NCTM *Standards* than the typical teacher. If so, they might be more likely to find the process of studying *Principles and Standards* engaging and meaningful. In addition, teachers who volunteered to participate in this professional development project might have been more prone to or ready for change than the typical teacher. In other words, the teachers who were drawn to participate in this project might be those who are especially interested in and ready to confront their beliefs and change their practice.

Second, I did not collect sufficient classroom observation data in order to make strong claims about the impact of the experience on teachers' practice. In particular, I did not collect data from teachers' classrooms *before* the study group began, and so I must rely solely on teachers' self-reports of what their mathematics instruction was like before joining the study group. Moreover, by only observing teachers' classrooms once or twice, I did not collect sufficient data to make strong claims about teachers' instruction during and after the study group sessions. Again, I had to rely primarily on teachers' self-reports of the changes they were making to their teaching.

## **Recommendations**

I conclude this chapter by drawing on the findings of this study and providing some recommendations for both future professional development endeavors and for future development of instructional policies.

### **Future Mathematics Professional Development**

First, I would recommend that future mathematics professional development projects consider seriously the use of study groups as the form or structure for the professional development. This study suggests that the study group was a powerful and effective medium for teachers' collaborative study of the document and for providing a safe and supportive environment in which teachers could take risks and try new approaches. Teachers especially enjoyed the collaborative nature of the study group. In fact, at the conclusion of the project, several teachers reported an interest in developing future study groups at their own schools. In particular, this study indicates that, with sufficient time and support, the study group developed into a learning community for teachers and supported them in moving toward developing critical collegueship (Lord, 1994). Of course, the form of any professional development project should be informed by the goals for that professional development. The use of study groups may not be appropriate if one's goals are to help teachers develop particular skills, such as using Geometer's Sketchpad or graphing calculators in their instruction.

Second, future mathematics professional development projects should consider seriously the incorporation of some piece from Principles and Standards. The document has quite a lot to offer, not only in mathematical content but in theories of mathematics



teaching and learning, and in broader mathematics education issues such as equity. It is difficult to imagine designing a professional development experience for K-12 mathematics teachers that would not be able to capitalize on at least some piece of the document. This study suggests that teachers are not only keenly interested in what the document has to offer, but also find the process of discovering this to be meaningful and educative.

### **Future Mathematics Instructional Policy Development**

The teachers in this study exhibited a willingness and ability to analyze and grapple with the ideas and recommendations put forth in *Principles and Standards*. Moreover, the results of this study indicate that their study of the document was a meaningful and educative experience. Thus, I would recommend that those who develop future mathematics instructional policies take advantage of these interests and capabilities by writing the document with teachers as one of the intended audiences. One way to do this is through the incorporation of vignettes and other examples that help illuminate the policy document's recommendations. The teachers in this study found the mathematics tasks, vignettes, and other classroom-based examples in *Principles and Standards* to be an important component in supporting their understanding of the document. Another way to compose policy with teachers in mind is to be thoughtful about the language, tone, and style. The teachers in this study were amazed at how reader-friendly the document was, and were appreciative of the limited use of "educational jargon".<sup>7</sup> They also found the

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<sup>7</sup> Also, recall Hill's (2001) discussion of the role of language in teachers' efforts to interpret educational policy.

document to be respectful and supportive of teachers. These qualities supported them in engaging with the document – they were both more willing and able to take up the ideas. Interestingly, when asked to compare and contrast *Principles and Standards* to another policy document, the Michigan Curriculum Framework, that did not have these features, they struggled to get engaged in this work. In particular, they found it difficult to interact with or make sense of the state’s framework, for it consisted primarily of lists of bulleted items detailing the mathematical content and processes students should learn in each grade. I was somewhat surprised by their reaction, for I anticipated that they would be very interested (if not more interested) in better understanding the recommendations put forth by their own state. However, despite my best efforts to keep them engaged in this work, teachers quickly dismissed this activity and insisted that we return to our discussion of *Principles and Standards*. By taking steps to make future instructional policy documents more accessible to teachers, policymakers not only support teachers’ learning of and about the policy, but also increase the likelihood that the policy recommendations will be attended to and implemented.

### **Future Research**

The results of this study suggest several areas and new questions for future research around the issue of how teachers make sense of instructional policy documents. First, I can envision follow-up studies to this one, in which researchers pursue these research questions, but with different populations of teachers. Recall that this study involved a group of middle school mathematics teachers. Future studies could investigate the effects of this type of work with teachers from other grade bands. For example, what

ideas might elementary school or high school mathematics teachers develop if they had opportunities to participate in a study group like the one I designed? It is not at all clear that we should anticipate similar results. In contrast to my teachers, who were primarily responsible for mathematics, and perhaps, science instruction, elementary school teachers are usually responsible for teaching every subject. Thus, it is not clear if they would be drawn to this type of work. In addition, their knowledge of mathematics is often underdeveloped. It might be necessary to build in different structures or experiences into the study group design in order to accommodate the special needs and interests of elementary school teachers. Similar questions can be asked about high school mathematics teachers. In particular, how might pressures to prepare students for college influence the ideas that high school teachers might develop about *Principles and Standards*?

In addition to varying the grade band of teachers involved, future research could investigate varying the composition of teachers involved. This study involved a diverse group of teachers from different schools and districts, using different mathematics curricula and working with different student populations. What ideas might mathematics teachers (in any grade band) develop, and what impact might the experience have on them, if they were to study *Principles and Standards* with colleagues from their own school or district? What role, if any, would contextual features play in this situation? One hypothesis would be that engaging in this type of work with colleagues from their own school or district would be a very powerful experience for teachers and might lead to greater impact within their school or district, as they would be able to provide each other with support on a day-to-day basis and would develop a stronger sense of unity and a

clearer direction for their school mathematics program. On the other hand, some researchers have wondered if teachers might be more reluctant to take risks and admit confusion and lack of knowledge publicly in front of colleagues from their own building (Wilson & Berne, 1999).

I am most intrigued by the prospect of investigating what role curriculum might play in supporting or constraining teachers' learning of and from *Principles and Standards*. Policymakers in education have often assumed that a policy's ideas can be readily and successfully communicated to teachers through the textbook they use (Cohen & Ball, 1990a, 1990b). The teachers in my study who were using the CMP curriculum (50% of the entire group) shared similar goals for students' learning, similar instructional activities, and similar experiences teaching mathematics, enabling them to develop rapport and trust more quickly than teachers who were not teaching CMP. The group also spent a good deal of time during the study group discussions discussing the curriculum and, at times, trying to get the non-CMP users "up to speed". What additional or new ideas might CMP teachers have developed about and from *Principles and Standards* if they had worked solely with other CMP teachers? How might limiting the study to teachers from one mathematics curriculum influence the nature of teachers' discussions in terms of their level of cognitive demand?

In addition to focusing on the role of a particular curriculum, future research should also investigate the role of curriculum more broadly. Would teachers using a *Standards-based* curriculum like CMP develop different ideas than teachers using a more traditional program? Teachers using *Standards-based* programs might tend to feel more validated by *Principles and Standards* and might be more likely to see the document as a

warrant for what they are already doing in their classrooms. Teachers using curricula that are not *Standards*-based might be more likely to see the document as a lever for changing what is happening in their classrooms. How might the level of alignment between teachers' curricula and the document influence their potential to experience dissonance through studying the document?

A unique aspect of the professional development project around which this research was conducted was that the project was purposefully designed so that participants would feel free to disagree with or question the document's recommendations and ideas. In other words, helping teachers to become advocates of *Principles and Standards* and supporting them in "implementing" the recommendations was not a goal of the professional development. Would the project have been more "successful" if I had strongly encouraged teachers to find ways to implement the document's recommendations? How might making this an explicit goal for teachers influence their discussions of the document, the ideas they developed, and the impact the experience had?

Future research should also investigate ways to support school administrators, curriculum supervisors, and teacher leaders in making sense of *Principles and Standards* and considering the implications for their work. Would an experience similar to the one I designed in this study – a study group of peers collaboratively studying the document – be meaningful and appropriate for these audiences? How might they interpret and react to the document's vision and recommendations? Would they develop similar views of the document, or would new views emerge? In particular, would they view the document as a site for their own professional learning, as many of the teachers in this study did?

Studies should also be conducted to investigate the ideas teachers develop from collaborative study of other instructional policy documents, such as the NRC's *National Science Education Standards* (1996). While I have proposed some hypotheses about why the teachers in this research study found their efforts to make sense of *Principles and Standards* to be engaging and meaningful, such as the inclusion of vignettes and mathematics tasks, such future studies would help us tease out which features of the policy documents are most crucial for and supportive of teachers' learning. These studies could also investigate what role content might play. In other words, might teachers react to and interpret standards for school mathematics differently than standards for school science? Findings from such studies could then inform the development of future instructional policies.

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## **APPENDIX A**

### **IRB APPROVAL AND CONSENT FORMS**

# UNIVERSITY OF NEW HAMPSHIRE

Office of Sponsored Research  
Service Building  
51 College Road  
Durham, New Hampshire 03824-3585  
(603) 862-3564 FAX

LAST NAME	Berk	FIRST NAME	Dawn
DEPT	Mathematics Department - Kingsbury Hall	APP'L DATE	10/6/2000
	8015 Bramblewood Drive #3A, Lansing, MI 48917	IRB #	2411
OFF-CAMPUS ADDRESS (if applicable)		REVIEW LEVEL	EXE
		DATE OF NOTICE	10/11/2000

PROJECT TITLE The Middle School Mathematics Standards Study Group

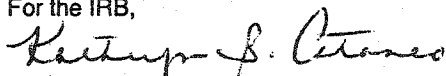
The Institutional Review Board for the Protection of Human Subjects in Research has reviewed the protocol for your project as Exempt as described in Federal Regulations 45 CFR 46, Subsection 46.101 (b) (2), category 1 .

Approval is granted to conduct the project as described in your protocol. **Changes in your protocol must be submitted to the IRB for review and approval prior to their implementation.** Also, if you experience any unusual or unanticipated results with regard to the participation of human subjects, please report such events to this office promptly as they occur. Upon completion of your project or after one year, whichever is shorter, please complete the enclosed pink Exempt Project Status Report form and return it to this office.

The protection of human subjects in your study is an ongoing process for which you hold primary responsibility. In receiving IRB approval for your protocol, you agree to conduct the project in accordance with the ethical principles and guidelines for the protection of human subjects in research, as described in the following three reports: Belmont Report; Title 45, Code of Federal Regulations, Part 46; and UNH's Multiple Project Assurance of Compliance. The full text of these documents is available on the OSR information server at [http://www.unh.edu/osr/compliance/Regulatory\\_Compliance.html](http://www.unh.edu/osr/compliance/Regulatory_Compliance.html) and by request from the Office of Sponsored Research.

If you have questions or concerns about your project or this approval, please feel free to contact me directly at 862-2003. Please refer to the IRB # above in all correspondence related to this project. The IRB wishes you success with your research.

For the IRB,



Kathryn B. Cataneo  
Executive Director  
Office of Sponsored  
Research

cc: File

Joan Ferrini-Mundy, MSU  
Karen J. Graham, UNH

February 15, 2001

Dear Teacher,

The purpose of this research study is to investigate how middle school mathematics teachers develop an understanding of NCTM's new standards document, *Principles and Standards for School Mathematics*. The study also aims to examine how teachers might use the document as a tool for reflecting on their practice and for understanding the issues and challenges involved in improving mathematics instruction.

To investigate these questions, a professional development experience – the Middle School Mathematics Standards Study Group, or (MS)<sup>2</sup> – has been developed. (MS)<sup>2</sup> will provide a forum in which middle school mathematics teachers form a study group to collaboratively examine, discuss, and reflect on the messages and ideas put forth in *Principles and Standards*. Participants will be assigned readings for each study group session, focusing on the Standards for Grades 6-8.

Teachers participating in the professional development project (MS)<sup>2</sup> will be asked to:

- Attend each study group session;
- Complete assigned readings for each study group session;
- Actively participate in study group discussions;
- Complete a survey questionnaire at the beginning and at the conclusion of the project;
- Develop, share, implement, and then revise a lesson plan;
- Maintain a dialogue journal.

For those teachers who consent to participate in the research component, their questionnaires, journal entries, and lesson plans will be collected, copied, and analyzed. In addition, teachers who consent to participate in the research will be asked to participate in a series of three interviews during the course of the project. The purpose of the interviews will be to attempt to better understand how teachers are thinking about and coming to understand *Principles and Standards*. Interviews should last about 1 hour each and will be audio taped and transcribed.

The study group will meet approximately twice a month at the Capital Area Science and Mathematics Center (CASM) in Lansing, MI from February to June, for a total of eleven three-hour study group sessions. Each study group session will be audio and video taped, and then transcribed.

The audio and video tapes from the study group sessions and the interviews will be used to analyze how subjects are developing an understanding of *Principles and Standards* and how their participation in the study group is helping them to reflect on their classroom practice. To maintain subjects' confidentiality, all collected data (audiotapes, videotapes, surveys, and copies of journal entries and lesson plans) will be stored in a locked file cabinet in a locked office. The data will only be accessible to Dawn Berk, the project director, the faculty advisors – Dr. Joan Ferrini-Mundy (Michigan State University) and



Dr. Karen Graham (University of New Hampshire), the project evaluator, Dave Kazen, and an undergraduate assistant who will help with the transcribing. The surveys, journal entries, and lesson plans will be treated as confidential. Subjects' privacy will be protected to the maximum extent allowable by law. Subjects will be given the opportunity to view the videotapes and decide whether they may be used at future talks. Any information gained as a result of a subject's participation will be provided to him/her upon request.

Each teacher participating in the professional development project will receive a copy of *Principles and Standards for School Mathematics*. Each teacher will also receive a stipend of \$825 (\$75 per study group session for 11 sessions), provided s/he attends each study group session, maintains the journal entries, and participates in the lesson plan development. **Each teacher admitted into the professional development project will receive this stipend, regardless of whether or not they consent to participate in the research.** Teachers can discontinue their participation in the professional development project at any time, but their stipend will be adjusted accordingly.

If you would like to participate in the research component, please read and complete the attached consent form. If you have any questions at any time during this project, please feel to contact Dawn Berk at (517) 432 – 9748 or Joan Ferrini-Mundy at (517) 432 – 1490. If you have questions pertaining to your rights as a research subject, you can also call the UNH Office of Sponsored Research at (603) 862-2003 or you can contact Dr. David Wright, the chair of the University Committee on Research Involving Human Subjects (UCRIHS) at Michigan State University at (517) 355 - 2180.

Sincerely,

Dawn Berk  
(517) 432-9748  
[berk@msu.edu](mailto:berk@msu.edu)

Joan Ferrini-Mundy  
(517) 432-1490  
[jferrini@msu.edu](mailto:jferrini@msu.edu)

## Informed Consent Document

### The Middle School Mathematics Standards Study Group

**Project Description:** The purpose of this research is to investigate how middle school mathematics teachers, through participation in a professional development project, develop an understanding of NCTM's new standards document, *Principles and Standards for School Mathematics*. The study also aims to examine how teachers might use the document as a tool for reflecting on their practice and for understanding the issues and challenges involved in improving mathematics instruction.

	Yes	No	Statement
1.			You have been informed that the University of New Hampshire Institutional Review Board for the Protection of Human Subjects in Research has approved the use of human subjects in this research.
2.			The scope, aims, and purposes of this research, the procedures to be followed, and the expected duration of your participation have been explained to you.
3.			You have received a description of any reasonable foreseeable risks or discomforts associated with being a subject in this research.
4.			You have received a description of any potential benefits that may be accrued from this research and how they may affect others and/or yourself.
5.			You have been informed of the procedures that are in place to maintain the confidentiality of all data and records associated with your participation in this research, including your identity. You have been informed that your privacy will be protected to the maximum extent allowable by law.
6.			You have been informed that consent to participate in this research is entirely voluntary, and that refusal to participate will involve no prejudice, penalty, or loss of benefits to which you would otherwise be entitled.
7.			You have been informed that if you consent to participate in the research, you may discontinue participation at any time without prejudice, penalty, or loss of benefits to which you would otherwise be entitled.
8.			You confirm that no coercion of any kind was used in seeking your participation in this research.
9.			You have been informed that if you have any questions pertaining to the research or any research related injury, you can call Dawn Berk at (517) 432-9748 or Joan Ferrini-Mundy at (517) 432-1490 and be given the opportunity to discuss them in confidence. If you have questions pertaining to your rights as a research subject, you can also call the UNH Office of Sponsored Research at (603) 862-2003 or you can contact Dr. David Wright, the chair of the University Committee on Research Involving Human Subjects (UCRIHS) at Michigan State

		University, (517) 355 - 2180.
<b>10.</b>		You have been informed that you will receive a stipend of \$75/study group session for a total of \$825 for participating in the professional development project, provided you attend each study group session, maintain your journal entries, and participate in the lesson plan development. You have been informed that you will receive the stipend, regardless of whether or not you consent to participate in the research.
<b>11.</b>		You have been informed that, upon request, any information gained about you as a result of your participation will be provided to you at the conclusion of your involvement in this research.
<b>12.</b>		You certify that you have read and understand the purpose of this research project and its risks and benefits for you as stated above.

I, \_\_\_\_\_, consent/agree to participate in this research.

Date: \_\_\_\_\_